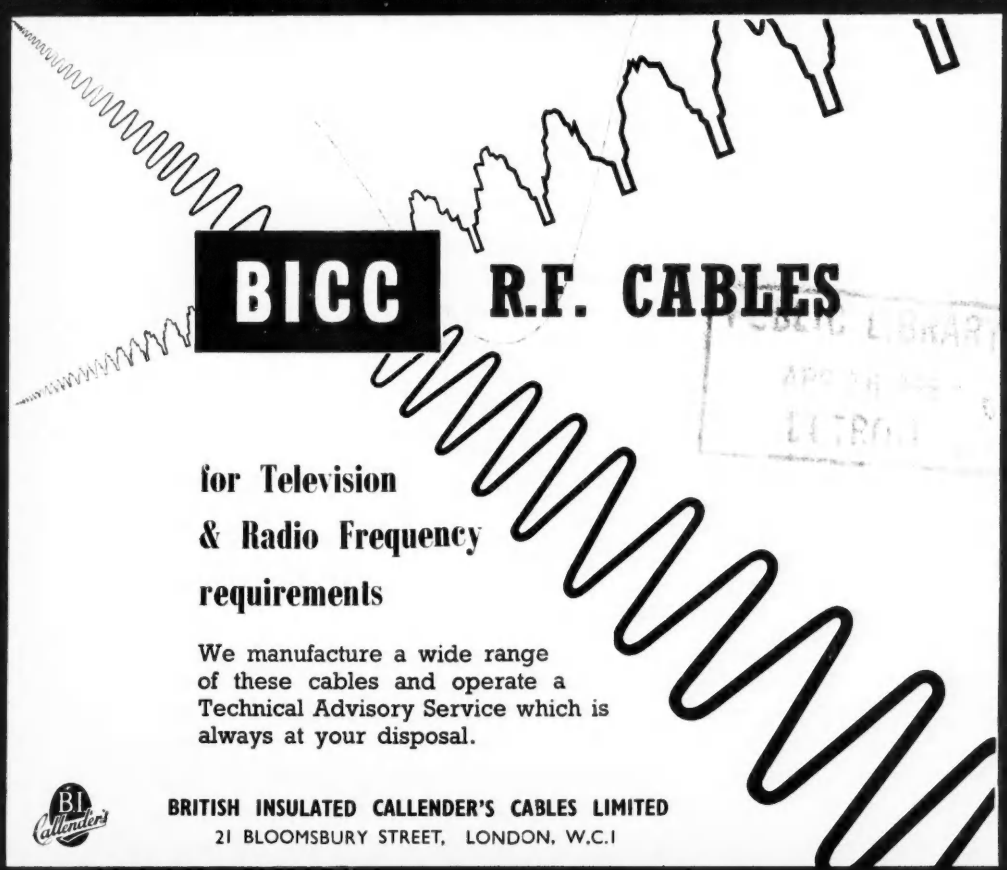
Electronic Engineering



BICC **R.F. CABLES**

for Television
& Radio Frequency
requirements

We manufacture a wide range of these cables and operate a Technical Advisory Service which is always at your disposal.

BICC Callender's

BRITISH INSULATED CALLENDER'S CABLES LIMITED
21 BLOOMSBURY STREET, LONDON, W.C.1

TWO SHILLINGS

DATA for the Designers File

Designers of medium power transmitters will want to know more about the Ediswan ESA.2500.

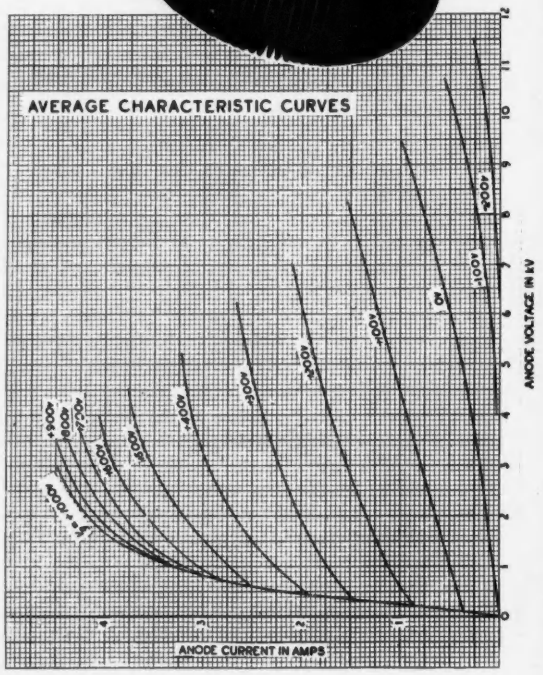
The Ediswan ESA.2500 is a forced air cooled triode designed for use as an R.F. Amplifier or Oscillator. The design of the valve is such that lead inductance is minimised and the valve is, therefore, particularly suitable for H.F. application.

RATING

Filament Voltage (volts)	V_f	8.0
Filament Current (amps)	I_f	80.0
Maximum Anode Voltage (volts)	V_a(max)	7,500
Average Maximum Filament Emission (amps)	Fe_m	4.5
Maximum Anode Dissipation (kW)	W_a(max)	2.5
Mutual Conductance (mA/V)	g_m	* 5.5
Amplification Factor	μ	* 55.0
Anode Impedance (ohms)	r_a	* 10,000
Maximum Operating Frequency at full rating		† 40 Mc/s

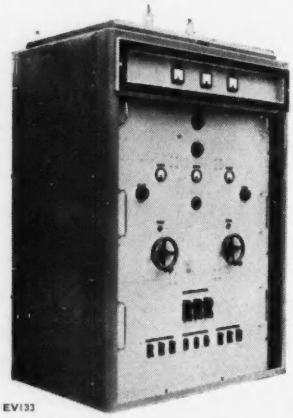
* Taken at V_a=7,000v; I_a=400 mA.

† At higher frequencies the maximum permissible anode voltages and inputs must be reduced.



REDIFON G.41. SHORT WAVE TRANSMITTER USES THE E.S.A. 2500 IN MODULATOR AND OUTPUT STAGES

This medium power short wave Transmitter can be used for Telegraphy, Telephony or Broadcast services in any part of the world. Power output is 5-7-5 kW on Telegraphy. Frequency range 2 to 23 Mc/s.



EV133

EDISWAN

INDUSTRIAL AND TRANSMITTING VALVES

THE EDISON SWAN ELECTRIC CO. LTD.
155 CHARING CROSS ROAD, LONDON, W.C.2

Member of the A.E.I. Group of Companies

955

CLASSIFIED ANNOUNCEMENTS

The charge for these advertisements at the LINE RATE (if under 1" or 12 lines) is: Three lines or under 7/6, each additional line 2/6. (The line averages seven words.) Box number 2/- extra, except in the case of advertisements in "Situations Wanted," when it is added free of charge. At the INCH RATE (if over 1" or 12 lines) the charge is 30/- per inch, single column. Prospectuses and Company's Financial Reports £14. 0s. 0d. per column. A remittance must accompany the advertisement. Replies to box numbers should be addressed to: "Electronic Engineering," 28, Essex Street, Strand, London, W.C.2. Advertisements must be received before the 14th of the month for insertion in the following issue.

OFFICIAL APPOINTMENTS

ASSISTANT (SCIENTIFIC). The Civil Service Commissioners invite applications for pensionable posts. Applications may be accepted up to 31st December 1955, but early application is advised as an earlier closing date may be announced either for the competition as a whole or in one or more subjects. Interview Boards will sit at frequent intervals. Age at least 17½ and under 26 years of age on 1st January, 1955 with extension for regular service in H.M. Forces, but candidates over 26 with specialized experience may be admitted. Candidates must produce evidence of having reached a prescribed standard of education, particularly in a science or mathematical subject. At least two years' experience in the duties of the class gained by service in a Government Department or other civilian scientific establishment or in technical branches of the Forces essential in one of the following groups of scientific subjects:— (I) Engineering and physical sciences. (II) Chemistry, bio-chemistry and metallurgy. (III) Biological Sciences. (IV) General (including geology, meteorology, general work ranging over two or more groups (I) to (III) and highly skilled work in laboratory crafts such as glass-blowing). Inclusive salary scale £262 (at 18) to £545 (men) or £457 (women). Starting pay up to £402 (men) or £357 (women) at 25. Somewhat less in provinces. Opportunities for promotion. Further particulars from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, W.1, quoting No. S 59/55. W 2999

BRITISH ELECTRICITY AUTHORITY. Eastern Division. Applications are invited for the following Superannuable post in the Technical (Electrical) Department based at Ipswich. General Assistant Engineer (Telecommunications) Salary Grade 6, £600×£25—£725/£785 per annum. Applicants should preferably possess Higher National Certificate in Electrical Engineering or equivalent qualifications and have considerable experience in the maintenance of automatic and line transmission telephone apparatus. Some knowledge of power supervisory systems and V.H.F. radio would be an advantage. The duties will be concerned with the Authority's telecommunications systems in East Anglia. Applications stating age, qualifications and experience should be sent to the Controller, British Electricty Authority, Eastern Division, Northmet House, Southgate, N.14, within 14 days of the appearance of the advertisement. W 2992

BRITISH EMPIRE CANCER CAMPAIGN. Electronics technician required to construct special apparatus for research and to assist with maintenance and operation of million volt electron accelerator. Age 22-35 preferred. Appointment will be either in the Technical Grade £470-£545, or in the Senior Technician Grade £570-£655, according to age and qualifications. Apply to Director, Research Unit in Radiobiology, Mount Vernon Hospital, Northwood, Middlesex. W 2988

ELECTRONICS ENGINEERS AND PHYSICISTS required for various posts in Research and Development Establishments of Ministry of Supply chiefly near Bournemouth, Hants; Malvern, Worcs; Farnborough, Hants; and London, H.Q. Applicants who have, or expect to obtain 1st or 2nd class Honours Degree or equivalent may be considered for Scientific Officer class: Salary within range £467 10s.-£845 provincial (London rate £25-£40 higher). Those with lower qualifications, e.g., Pass Degree, H.N.C. Final C. and G. Cert., etc., minimum Higher School Certificate (Science) may be considered for Experimental Officer class: Salary according to age, experience, etc., within range E.O. (min. age 26) £715-£880; Assistant E.O. £288 10s. (age 18)—£640 provincial (London rate £14-£40 higher). Salary rates for women somewhat less. F.S.S.U. Benefits may be available for S.O. class. Possibilities of promotion. Not established but opportunities to compete for establishment may arise. Application forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D81/5A. W 2967

ELECTRICAL ENGINEERS required for various Research and Development Establishments of Ministry of Supply at Farnborough, Hants; Malvern, Worcs; Sevenoaks, Kent; Christchurch, Hants; and London H.Q. Applicants should have or be expecting to obtain a 1st or 2nd class Honours Degree or equivalent preferably with experience in light electrical or electronic engineering fields. Initial appointment to Scientific Officer grade. Salary, according to age, experience, etc. within range £467 10s. -£845. (£25-£40 higher in London). Women somewhat less. Prospects of promotion. Not established but opportunities to complete for establishment may arise. F.S.S.U. benefits may be available. Application forms from M.L.N.S. Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D 63/5A. Closing date 8 April 1955. W 2966

ELECTRONIC ENGINEER REQUIRED for work with Research Unit of Medical Research Council. Duties: development of experimental electronic equipment, chiefly in audio-frequency range. Qualifications: H.N.C. Grad. I.E.E. or equivalent. Commencing salary in the range £600-£800 according to experience and qualifications. The successful applicant would be required to join the Council's superannuation scheme after a satisfactory probationary period. Apply to The Secretary, Otological Research Unit, Medical Research Council, National Hospital, Queen Square, W.C.1. W 3027

ESSEX EDUCATION COMMITTEE. South-East Technical College and School of Art, Longbridge Road, Dagenham. Required 1st September, 1955. Assistant Grade B for Radio and Television Servicing and Telecommunications. Salary £525 × £25 to £820, plus London Allowance, with additions for approved experience, training and qualifications. Application forms (returnable within 14 days) and details from Clerk to the Governors. W 3032

MINISTRY OF SUPPLY requires Radio/Radar Technicians in Buckinghamshire to help equipment investigations and installation design of pulse and C.W. navigational aid systems and long distance and mobile radio installations. Qualifications. British of British Parents. Recognized engineering apprenticeship or equivalent in radio industry. Experience with installations of type specified. H.N.C. or O.N.C. or appropriate City and Guilds or equivalent qualification desirable. Salary. Three grades within £535 (age 26)—£945 according to age and qualifications. Not established but opportunities to compete for establishment may arise. Application forms from M.L.N.S. Technical and Scientific Register, (K) 26 King Street, London, S.W.1, quoting D60/5A. Closing date 9th April, 1955. W 2914

MINISTRY OF SUPPLY requires Technical Authors at Chessington (also for posts (b) at Farnborough and Malvern), for publications dealing with all aspects of (a) mechanical and electro-mechanical equipment related to guided weapons or telegraphy, telemechanics and radio (Ref. D87/5A); (b) airborne/ground electronic equipment relating to radio communications, radio/radar control, search and navigation or guided weapons (Ref. D88/5A); (c) aircraft instruments, training aids and photographic equipment (Ref. D89/5A); (d) aircraft electrical, instrument and radio installations or ground servicing and test equipment (Ref. D90/5A). Qualifications: British of British Parents. Recognized engineering apprenticeship or equivalent with A.M.I.C.E. or Mech.E. or E.E. or A.F.R.Ae.S. or H.N.C. or O.N.C. or equivalent. Experience: Posts (a) development or operation and maintenance of equipment concerned, and for guided weapons knowledge of servo-mechanisms and electronic devices desirable: Posts (b) development or operation and maintenance of radio equipment: Posts (c) electrical and mechanical instruments particularly for aircraft, apprenticeship in instrument making preferred; Posts (d) appropriate experience. Except for (c) experience of writing or editing technical publications advantageous. Vacancies in three grades at salaries between £645 and £1,015, according to age and qualifications. Not established, but opportunities to compete for establishment may arise. Application forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, S.W.1, quoting appropriate reference. W 2998

MINISTRY OF SUPPLY invites applications for a limited number of Senior and Junior Fellowships tenable for three years at the Radar Research Establishment, Malvern, Worcs, commencing in Autumn, 1955. Candidates must be British subjects with normally either a First or Second class Honours degree in an appropriate subject and must be able to show evidence of a very high standard of ability in research. Exceptionally a candidate without the academic requirement, but who can produce evidence of outstanding ability in research may be admitted. Fellows will be allowed considerable choice of subjects within the fields of interest to the Establishment. These include experimental and theoretical research in low temperature physics, electrical and optical properties of semi-conductors, infra-red spectroscopy, microwave physics, and electronics. For Junior Fellowships candidates should have had at least two years' post graduate research experience and should preferably be aged 23-26; candidates for Senior Fellowships should have had at least three years' post graduate research experience and should preferably be aged 26-30. Remuneration will depend on individual merit and will be between £950-£1,150 per annum for Senior Fellows and £600-£800 per annum for Junior Fellows. Successful candidates will have their appointments brought under F.S.S.U. At the expiry of a Fellowship a holder may be considered for an established post at the Establishment if he so desires. Application forms obtainable from the Director, Radar Research Establishment, Malvern, Worcs, to whom they must be returned by 15th April, 1955, together with suitable testimonials regarding research ability, and, where possible, copies of candidates' published papers. W 3021

NATIONAL INSTITUTE FOR MEDICAL RESEARCH, The Ridgeway, Mill Hill, N.W.7 requires an Assistant for the Instrument Laboratory. Minimum qualification: G.C.E. ordinary level or equivalent with passes in English, Mathematics and Physics; experience of the production and experimental apparatus and some knowledge of electronics are desirable. Initial salary £450 plus London weighting of £20-£30 depending on age. Three weeks holiday with pay. Established superannuated post after probationary period. Excellent conditions. Apply in writing to Administrative Officer at above address. (Quote ref: AD/54). W 2989

NORTHAMPTON POLYTECHNIC, E.C.1. Department of Electrical Engineering. Required, Laboratory Technician. Post offers experience, training and education in all aspects of electrical engineering with light current or power specialization. Part time day education for Degree or H.N.C. Five weeks paid holiday annually. Salary: age 16 £3 13s. 6d. to £401 p.a. at approximate age 26, plus supplement for certain qualifications. Post superannuable. Applications to Head of Department. W 2923

NORTHAMPTON POLYTECHNIC, London, E.C.1. Chief Laboratory Technician for applied physics required. Knowledge of Physics and laboratory and workshop experience necessary. Post involves assisting in development of laboratories and also some responsibility for junior staff. Preference given to man keen on continuing his studies. Five weeks paid holiday annually. Superannuation scheme. Scale: £503 by £25 10s. to £580 per annum. Apply by letter to the Secretary. W 2924

UNITED KINGDOM ATOMIC ENERGY AUTHORITY, A.E.R.E., Harwell, Berks requires a Senior Experimental Officer in its Health Physics Division to direct a team en-

gaged in the calibration and maintenance of installed and portable electronic radiation monitoring instruments used in the control of health hazards and in the development and construction of small numbers of special health radiation instruments. He will also have to arrange, through Electronics Division, for the specification and supply of new health radiation instruments at A.E.R.E. Applicants should be at least 31 years of age, and possess minimum qualifications of Higher School Certificate, or equivalent qualifications. They should have had experience in the field of electronics. A knowledge of methods of measurement of ionising radiation and experience of maintenance work on electronic instruments would be an advantage. The successful candidate will be appointed according to age, experience and qualifications within the salary scale £1,090-£1,285 p.a., and will be required to join the Establishment s contributory superannuation scheme. Applications should be sent to Establishment's Officer, United Kingdom Atomic Energy Authority, A.E.R.E. Harwell, Berks, quoting 2/103/241. W 2928

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY, Foulness, Essex requires Senior Scientific Officers or Scientific Officers as follows:— Post 1. (B214/WGE/42) To develop and use instruments to record ground shock from high explosives and Atomic Weapons. Minimum qualification is first or second class Honours Degree in Physics, preferably with experience of accelerometers and electronic transducers. Post 2. (A285/WGE/42) A Physicist or electronic engineer to devize and develop instruments to record air blast from high explosives and Atomic Weapons. Minimum qualification is first or second class Honours Degree in Physics. Experience of magnetic tape recording techniques would be desirable, but not essential. Applicants for the S.S.O. grade should have had some years appropriate post-graduate research experience. The salary ranges are Senior Scientific Officer £1.040-£1,205 (male) per annum and Scientific Officer £505-£905 (male) per annum. The starting salary of a Scientific Officer is assessed according to age, qualifications and experience. The successful applicants will be required to join the Authority's Principal Superannuation Scheme and contribute 6 per cent of salary. Application form from Senior Recruitment Officer, A.W.R.E. Aldermaston, Berks. Quote appropriate reference. W 2935

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY. Aldermaston, Berks, requires Senior Scientific Officers and Scientific Officers for mainly electrical engineering duties, specializing in communications or electronics, including the following items:— Spark discharge phenomena, radar circuits and measurements, high speed and short duration pulse circuits. high voltage techniques, ultra high frequency and very high frequency communication problems, very wide band I.F. and video amplification telemetry. Applicants should have a first or second class Honours degree in electrical engineering or physics with a bias toward electronics. Previous experience in the above fields will be advantageous. For the S S.O. grade some years appropriate post-graduate research experience is essential. Salary Ranges: Senior Scientific Officer £1,040-£1,205 (male) per annum. Scientific Officers £505-£905 (male) per annum. The starting salary of a Scientific Officer is assessed according to age, qualifications and experience. Successful candidates will be required to join the Authority's Contributory superannuation scheme. Housing accommodation will be available within a reasonable period for married staff who live outside the radius of the Establishment's transport facilities. During this period lodging allowance may be payable to suitably qualified candidates. Successful applicants may be required to serve an initial period of detached duty at Fort Halstead, Kent. Send postcard for application form to Senior Recruitment Officers, A.W.R.E., Aldermaston, Berks. Quote Ref: 537/WGE/42. W 3020

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY, invites applicants for post of Deputy Chief Engineer at the Atomic Weapons Research Establishment, Aldermaston, Berks. Applicants should have a wide knowledge of the design and development of complex experimental equipment for service use. They must possess a comprehensive knowledge of running a large engineering team, in close collaboration with scientists. Some knowledge of electronics and experience in the handling of explosives are desirable. The post would entail the supervision of the following branches: mechanical engineering, electronic engineering, planning and maintenance of buildings and a design office. A comprehensive service on all design work in addition to maintenance and general engineering will have to be rendered. Applicants should have a Degree in engineering or equivalent qualifications and must have had previous experience of handling large numbers of qualified engineers and industrial staff. There is a contributory pension scheme. Applications to J.R.V. Dolphin, Chief Engineer, through Chief Personnel Officer, A.W.R.E., Aldermaston. Berks. W 3034

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY, Aldermaston. Berks, requires an Engineer (Basic Grade) or Experimental Officer to assist in the planning and execution of overseas trials of atomic weapons. This will involve the co-ordination of the engineering effort involved in the installation of test structures required by the various participating organizations. For an Engineer (Basic Grade) post, applicants should have served a recognized engineering apprenticeship and either be corporate members of one of the institutes of Civil, Mechanical or Electrical Engineers, or have exempting qualifications. The salary scale is £695-£1,065 (male) p.a. For an Experimental Officer post, the minimum qualification is Higher School Certificate or equivalent, or Higher National Certificate in Physics or Civil Electrical or Mechanical Engineering. Civil and Mechanical engineering experience in the field, and experience in planning installations for field trials is desirable. The salary scale (minimum age 26) is £775-£945 (male) p.a. The successful applicant will be required to join the Authority's Principal Superannuation Scheme and contribute 6 per cent of salary. Housing will be available within a reasonable period for married officers who live outside the radius of the Establishment's transport facilities. During this period lodging allowance may be payable to suitably qualified candidates. Application form from Senior Recruitment Officer, A.W.R.E., Aldermaston, Berks. Quote Ref. 532/WGE/42. W 3011

UNITED KINGDOM ATOMIC ENERGY AUTHORITY. A specification writer for Airborne Service Electronic Equipment is required at the Atomic Weapons Research Establishment, Aldermaston, Berks. The successful applicant will be in charge of a small group of Specification Writers. Applicants should have served a recognized engineering apprenticeship or have had equivalent training and experience in Electrical or Electronic Engineering. Experience in testing prototype and/or initial production electronic equipment and in specification writing is desirable. The post is in the Technical Class and the salary scale is £830 rising to £1,015. The successful candidate will be required to join the Authority's Superannuation Scheme and contribute 6 per cent of his salary. Housing accommodation will be available within a reasonable period for married officers who live outside the radius of the Establishment's transport facilities. It may be necessary for a short period of outstation duty to be served at Fort Halstead, Kent. Application form from Senior Recruitment Officer, A.W.R.E., Aldermaston, Berks, quoting reference 302/WGE/42. W 2946

UNIVERSITY OF CAMBRIDGE, Department of Physical Chemistry. A Research Assistant is required in the Research Laboratory on the Physics and Chemistry of Surfaces for work involving the maintenance, application and development of an electron microscope and diffraction camera, used in the research programme of the Laboratory. Applicants should have a good technical qualification or scientific training and preferably some experience of vacuum technique or electronics. The position is unestablished and the salary will be about £400 p.a. Applicants should submit a brief account of their experience and qualifications, mentioning age, to the Secretary, P.C.S. Laboratory, Department of Physical Chemistry, Free School Lane, Cambridge. W 2929

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY, Aldermaston, Berks, requires a number of Design Engineers to lead groups engaged upon the design and development of electrical/electronic engineering requirements. Applicants should possess a Degree, preferably with Honours, in Electrical Engineering or Electrical (Telecomms.) and have had considerable workshop experience. They should have had a number of years' experience in electrical/electronic design, and should have been in control of complete projects, and have carried them through to the final stage. A high standard of technical judgment is essential and initiative, drive and adaptability is required. The salary will be up to £1,500 per annum (male) according to qualifications and experience. Successful candidates will be required to join the Authority's contributory superannuation scheme. Housing accommodation will be available within a reasonable period for married staff who live outside the radius of the Establishment's transport facilities. Send postcard for application form to Senior Recruitment Officer, A.W.R.E., Aldermaston, Berks. Quote Ref. 566/WGE/42. W 3033

TRINITY HOUSE, LONDON. Radio Maintenance Assistants wanted:— Radio Maintenance Assistants are required to maintain radio and radar equipment in shore stations and ships. Candidates must possess a knowledge of the fundamental principles of radio and radar and must have had practical experience in the maintenance and use of such equipment They should be medically fit and of British Nationality. Some of the appointments are permanent and pensionable subject to one year's probation. Salary scales £565 rising to £695 (minimum linked to age 26) or £452 10s. rising to £610 (minimum linked to age 25) depending on qualifications and experience. Applications to be made in writing to The Secretary, Trinity House, London, E.C.3, not later than 18th April 1955 stating age, present occupation, qualifications, experience and enclosing copies of testimonials. W 3056

UNITED KINGDOM ATOMIC ENERGY AUTHORITY, Aldermaston, requires a Technician to be responsible to a Senior Engineer for the efficient operation of a group of workshops engaged on the manufacture of a wide range of experimental electronic equipment. Applicants should have served a recognized engineering apprenticeship. Previous experience in both mechanical precision instruments (e.g., light machining, fitting and sheet metal work) and electronic work (e.g., wiring and assembly, transformer winding) associated with the small quantity production of electronic equipment is essential. Previous experience with plastics as applied to electronic work would be an advantage. Possession of Higher National Certificate or equivalent qualification is desirable. Salary: £830 to £1,015 (male). The successful candidate will be required to join the Authority's Superannuation Scheme and contribute 6 per cent of salary. Housing will be available within a reasonable period of time for the selected candidate who is married and lives outside the radius of the Establishment's transport facilities. During this period, lodging allowance may be payable to suitably qualified candidates Application forms from Senior Recruitment Officer, A.W.R.E., Aldermaston, Berks, quoting reference 528/WGE/42. W 2982

CLASSIFIED ANNOUNCEMENTS
continued on page 4

World-wide testimony

EVERY CLAIM we have made for these remarkable units has been substantiated by users and experts (including F. J. Camm, John Gilbert, P. Wilson, H. J. Barton-Chapple and L. Ormond Sparkes) — they have produced the largest volume of unsolicited testimony ever known in the history of loudspeaker manufacture.

From every part of the world we are told that the quality of reproduction is unrivalled except at many times the price — that these units have enabled everyone to enjoy High Fidelity at realistic cost.

We are truly grateful for this amazing response.

Points to note: patented Cambric Cone, high flux density Alcomax magnet, die-cast chassis, Universal impedance speech coil (at 3, 7.5 and 15 ohms) on 8, 9 and 10 inch models.

Prices from **37/6** to **£9.15.6** (tax paid).

Ready-to-assemble Bass Reflex Console Cabinet for 10″ or 12″ unit, **£10.10.0.**
Corner Console Cabinet for 8″ unit, **£5.10.0.**

Write for leaflets, or see and hear them any Saturday betweeen 9 a.m. and 12 noon at our London Office, 109 Kingsway, W.C.2.

Prov. Patent 10037/53

Stentorian CAMBRIC CONE **HI-FI UNITS**

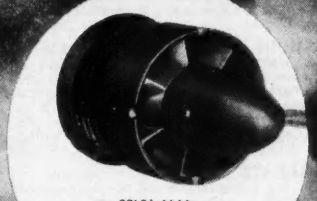
WHITELEY ELECTRICAL RADIO CO. LTD., MANSFIELD, NOTTS

WB

Plannair blowers chosen for the de Havilland Venom Mk.3

type 3PL181-H blower A.M. Type 13. Stores Ref: 5UD/6204.

You are invited to write for full specifications and performance curves of the wide range of Plannair Axial Flow Blowers designed for a variety of airborne, marine and ground applications.



type 2PL81-H blower A.M. Type 12A. Stores Ref: 5UD/6205.

PLANNAIR *FOR THE WORLD'S FINEST AIRCRAFT*

PLANNAIR LIMITED WINDFIELD HOUSE LEATHERHEAD SURREY TEL LEATHERHEAD 4091/2231

TELEGRAMS & CABLES: PLANNAIR LEATHERHEAD *FACTORY: GOBLIN WORKS LEATHERHEAD*

4507

UNIVERSITY COLLEGE OF NORTH WALES. Applications are invited for the post of Technician in the Department of Applied Electricity. Salary £340 by annual increments of £15 to £415 (efficiency bar) then £440 by £20 to £480 per annum. Experience in the servicing of electronic apparatus is desirable. Applications giving particulars of age, experience, etc., and the names and addresses of two referees should be sent to reach the Registrar, University College of North Wales, Bangor, not later than Monday, 16th May, 1955. W 3049

VACANCIES IN GOVERNMENT SERVICE at Cheltenham. 1. Instrument Makers with fitting and machine shop experience in light engineering. 2. Teleprinter, Radio and Electronic Mechanics and Assembler Testers with experience of telecommunications equipment. Basic Pay: £7. 7s. 10d. plus merit pay up to £2. 10s. assessed at interview, based on ability and experience. Opportunities for permanent and pensionable posts. Apply in writing only, giving personal particulars to Personnel Officer, G.C.H.W. (Foreign Office), 53 Clarence Street, Cheltenham. W 3029

WIRELESS STATION SUPERINTENDENT required for the Posts and Telecommunications Department Gold Coast Local Civil Service, for two tours of 18 to 24 months in the first instance. Consolidated salary scale £990 rising to £1,230 a year. Gratuity at the rate of £100/£150 a year. Outfit allowance £60. Liberal leave on full salary. Free passages. Candidates should possess C. and Gds. Final Certificate in Telecommunications (Radio) or C. and Gds. Certificates Radio III and IV equivalent, and have had three years' experience in two or more of the following fields: V.H.F. link systems; H.F. communications systems; Frequency shift keying and teleprinter maintenance; V.H.F. and H.F. Cathode Ray Direction finding systems; Aeronautical navigation aids (ground); Manufacture of light engineering equipment. Candidates from the British Post Office should apply through departmental channels. Write to the Crown Agents, 4 Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M2C/29100/EK. W 2962

SITUATIONS VACANT

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 *inclusive or a woman aged* 18-59 *inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order,* 1952.

A DRAUGHTSMAN preferably under 30 years of age, with experience of light electromechanisms, instruments, or both is required for a small team engaged in the design and manufacture of special purpose apparatus. A sound background of workshop experience is essential. The appointment is at the applicational research centre of a Major Oil Company near Chester. Starting salary according to age and experience. Attractive Pension Benefits. Write giving full details to Box ZV, 707 Deacon's Advertising, 36 Leadenhall Street, London, E.C.3. W 2843

A. H. HUNT (CAPACITORS) LIMITED require engineers for design and development of paper, mica and ceramic capacitors. Applicants should have previous training in electrical engineering at least to intermediate B.Sc. standard. Apply Personnel Manager, A. H. Hunt (Capacitors) Limited, Bendon Valley, Garratt Lane, Wandsworth, S.W.18. W 212

A GRADUATE PHYSICIST is required to work on the measurement of the fundamental properties of a wide range of semi-conductor materials. The work involves the development of original methods and equipment. Previous experience in the field would be advantageous, but is not essential. Box No. W 2921.

AIRCRAFT ELECTRICAL DESIGN DRAUGHTSMEN required. Excellent opportunities for advancement. Apply Personnel Department, Vickers-Armstrongs Ltd., Hursley Park, Nr. Winchester. W 2849

AIRCRAFT RESEARCH ASSOCIATION LTD. Instrumentation Engineers. Vacancies exist in a team now being established for the design installation and operation of a scheme of fully automatic instrumentation for a new wind tunnel. A variety of new measurement problems are being undertaken and the posts offer scope for originality and inventiveness. Applications are invited from:— (A) Young Graduates (or H.N.C. or equivalent) in Electrical Engineering or Physics. Prepared to be responsible for design, development and manufacture of electrical and electro-mechanical instrumentation. (b) Engineers with National Certificate or similar qualifications in Electrical, Radio or Telecommunication Engineering to participate in development, calibration and operation of instrumentation schemes. (c) Mechanics, Servicemen or Wiremen to undertake construction and maintenance of electrical measuring apparatus. Relevant experience in the fields of Electronics, Telemetry, Computors, Telephone Practice, Servos, etc. will be an advantage but is not essential. Good salary and Pension Scheme. Apply in writing to Chief Executive, Aircraft Research Association Ltd., 33 Midland Road, Bedford. W 1299

A JUNIOR PROJECT ENGINEER required by expanding Company having established development and production interests in audio and precision electro-mechanical fields and considering new industrial electronic products. HNC desirable although not essential, but the successful applicant must have three years' experience of laboratory or test work, ability to analyse circuit requirements into a sound choice of components, and a general knowledge of basic electronic circuitry and equipment construction methods. Good progressive salary and pension scheme offered. Western London area. Applications should give full details of age, training and experience. Box No. W 3019.

A LARGE AND WELL ESTABLISHED Engineering Company situated in the East London area require tool designers and draughtsmen. Applicants should have had toolroom apprenticeship or equivalent, followed by experience on first-class tool design work in the light mechanical and electrical fields. Applications are invited from men of sufficient experience and ability to justify very good salaries. Excellent working conditions, and staff pension scheme in operation. Please write, in confidence, giving details of experience to Box No. W 2945.

A LIGHT ENGINEERING CO., in West London has vacancies for Engineers and Physicists in their Magnetic Recorder Design Laboratory. Preference will be given to applicants experienced in this work and who are capable of accepting responsibilty. Salary will be according to age and experience. Write giving age and fullest details of experienc to Box No. W 2948.

AMBITIOUS AND ENERGETIC ENGINEERS are invited to apply for the following posts:— 1. Senior position for a competent valve engineer to study and advise on the use and application of valves in a wide range of electronic equipments and to liaise with valve manufacturers. Applicants must have experience suitable for the position, and a sound knowledge of microwave valves. 2. Senior Microwave Engineers for development of microwave components and aerials. Qualifications and experience essential. 3. Senior Engineers capable of controlling a project from "bread-board" to production. Applicants must have at least three years' development experience. These posts are for permanent pensionable staff in a rapidly expanding Development Division offering unique opportunities for advancement to those who are prepared to work hard and produce results. Write to: Chief Development Engineer, Decca Radar Ltd., 9 Davis Road, Tolworth, Surrey. W 3001

AN ELECTRONIC or Electrical Engineer aged between 25/40 years of Degree standard, is required to take charge of the Electrical Development Laboratory in an old-established Company engaged in the mass production of electrically operated clockwork mechanisms. The position offers a wide scope to one possessing the initiative to expand the work along numerous channels. Modern factory situated in Somerset. Every assistance given with obtaining accommodation. Write giving full and complete details of qualifications, experience, salary envisaged to Box No. W 1297.

APPARATUS ENGINEERS. Standard Telephones & Cables Ltd., have vacancies for Apparatus Engineers in the fields of Electro-Acoustics telephone exchange switching apparatus and electronics switching designs and developments. The work is varied and involves carrying through designs and developments to the production stage together with associated laboratory and investigational work. An engineering or physics Degree is desirable, but H.N.C. standard will be considered. Salaries will be paid according to age, qualifications and experience. Write in confidence giving full particulars to Personnel Manager, Oakleigh Road, New Southgate, N.11. W 3017

ASSEMBLER/FITTER, aged 21-30, experienced precision electro mechanical assembly. Full details L.M.K. Manufacturing Co. Ltd., Harlequin Avenue, Great West Road, Brentford, Mdx. W 1312

A SENIOR COMMUNICATIONS ENGINEER is required for responsible post on design of Carrier Telephony Radio Links. Applicants should have a good engineering or science Degree, or equivalent qualifications and at least five years' experience in a similar post. Applications should be addressed to Personnel Department, S.C.E., Murphy Radio Ltd., Welwyn Garden City. W 3014

A SENIOR ENGINEER is required for a responsible post on design of Communications Receivers and Low Power V.H.F. R/T Equipment. Applicants should have a good engineering or science degree, or equivalent qualifications and at least five years' experience in these fields in responsible positions. Applications should be addressed to Personnel Department, S.E., Murphy Radio Limited, Welwyn Garden City. W 3013

ASSISTANT TO THE CHIEF ENGINEER required by an established instrument company in the Home Counties, now pioneering new developments in the field of electronic technology. While academic qualifications are not essential, applicants should have a sound theoretical training and considerable practical experience. The salary will be according to experience—£1,200 per annum is envisaged. There is a pension scheme. Box No. W 2848.

A TRANSISTOR CIRCUIT ENGINEER is required in the Transmission Laboratory for development work on testing apparatus. Excellent opportunity for a qualified Physicist or mathematician interested in the application of semi-conductors. Previous experience is desirable but not essential. Apply, giving details of qualifications, experience and salary required to the Personnel Manager, Standard Telephones & Cables Ltd., Corporation Road, Newport, Mon. W 1314

AUTOMATIC TELEPHONE & ELECTRIC CO. LTD. Liverpool, 7. Communication Engineers and Draughtsmen, The expanding programme of the Transmission Department offers vacancies in both senior and junior categories for Line Transmission Laboratory Engineers, and Apparatus Design Engineers, and also for Draughtsmen with experience in telecommunications or light current engineering. Specialist experience in any branch of Line Transmission Engineering is desirable for some of the posts. Positions offered are on the Company staff with contributory Pension Fund and usual staff conditions. Applicants should write to Personnel Manager, Automatic Telephone & Electric Co. Ltd., Strowger Works, Edge Lane, Liverpool, 7, giving full details of age, qualifications and experience. W 2876

AUTOMATIC PROCESS CONTROL. Imperial Chemical Industries Limited is about to expand its Central Instrument Laboratory, which will shortly have new accommodation in the Pangbourne area. The Laboratory has the responsibility of studying the fundamentals of automatic process control, and of carrying out research on control equipment and the plant design factors which determine controllability. The work is the responsibility of a number of teams devoted to the study of particular aspects, such as plant characteristics, individual processes, computors suitable for process control, complex control systems, control criteria, etc. There are vacancies in these teams for Chemical Engineers, Electrical and Electronic Engineers, Physicists and Physical Chemists. Applicants with suitable

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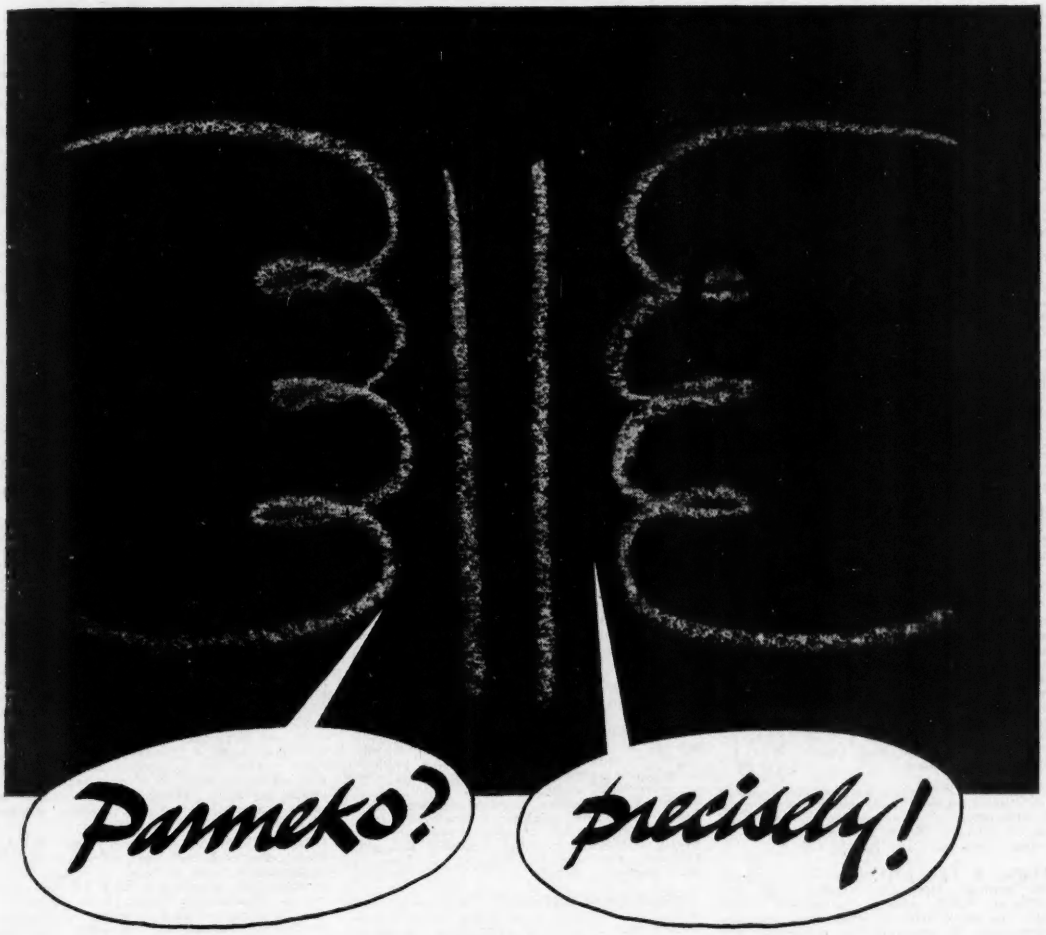

This space is oaned by PARMEKO for the delight of doodlers in the hope that they may improve on the above.

PARMEKO *of* **LEICESTER**

MAKERS OF TRANSFORMERS FOR THE ELECTRONIC AND ELECTRICAL INDUSTRY

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

experience and qualifications will also be considered to fill one vacancy as a team leader. In addition, men (preferably over 35) with outstanding experience in any of these fields, are required to fill three senior posts, for which the salaries will be commensurate with the experience required. Application forms may be obtained from the Head Office and Regions Staff Department, Imperial Chemical Industries Limited, I.C. House, Millbank, S.W.1. W 3039

AUTOMATION ENGINEERS required for a new Development Section. Vacancies exist for: 1. Project Engineer, responsible to the Section Head for engineering from the mock up stage and liaison with customers, Ministries, subcontractors and own development sections. Electrical Engineering apprenticeship with electronic experience and A.M.I.E.E. or H.N.C. preferred. 2. Electronic Development Engineer with previous laboratory experience in photo-electrics and servo-mechanisms. O.N.C. or equivalent. 3. Design Draughtsman with electro-mechanical experience. Good prospects, salaries commensurate with qualifications and experience. Apply Personnel Manager, Electronics Division, Hi'ger & Watts Ltd., 48 Addington Square, London, S.E.5. W 2995

A VACANCY EXISTS for an E'ectronic Instrument Development Engineer in the Telecommunication Laboratory of British Insulated Callender's Cables Ltd., at Kirkby, near Liverpool. Candidates should hold a Degree in Physics or Engineering and have previous experience in the design and development of Electronic Instruments. Some experience of servo-mechanisms would be an advantage. Applications quoting reference P/60/54 should be addressed to: The Staff Officer, B.I.C.C. Ltd., Prescott, Lancs. W 2931

A WELL-KNOWN research institute requires an electrical engineer with university training and experience of servo-mechanisms on analogue computors. Salary commensurate with age and experience. Box No. W 1294.

BELLING & LEE LTD. wish to engage a young graduate electronics engineer with experience of V.H.F. receiver layout and circuit design, the work being in connexion with the development of measurement apparatus for their television aerial laboratory, and communal broadcast and television amplifiers: British nationality essential: contributory pension scheme. Applications (which will be treated in confidence) stating age, experience and salary required to the Secretary, Great Cambridge Road, Enfield, Middlesex. W 1296

BTH RESEARCH LABORATORY requires engineers with a Degree or national certificate in electrical engineering who are interested in light current or radio, for testing high power microwave valves, and for the design construction, and maintenance of electrical pulse test equipment, including modulators, cathode ray oscillographs and automatic control circuits. The work in any one of these fields is varied and interesting, and will be carried out in co-operation with a team engaged in research on microwave valves. Application should be made to the Director of Research, British Thomsoon-Houston Co. Ltd., Rugby, quoting reference DR3, and giving age, qualifications and experience. W 2974

BTH RESEARCH LABORATORY requires honours graduates in physics or electrical engineering to join a section engaged in the development of microwave electronic valves. The vacancies are in a group whose primary function is to investigate the fundamental operating mechanisms of established devices such as magnetrons and klystrons and to evolve new types of microwave oscillator. Successful applicants will be required to show initiative and ability to a standard corresponding to work leading to a post graduate degree; they will work in a new laboratory, exceptionally well equipped, and provided with adequate constructional and general engineering facilities. Applications should be made to the Director of Research, British Thomson-Houston Co. Ltd., Rugby, quoting Ref. DR2 and giving age, qualifications and experience. W 2975

BUSH RADIO LTD. require Senior and Junior Engineers in their Laboratories at Chiswick, Kew and Plymouth. Applicants should preferably hold a Higher National Certificate, B.Sc. Engineering or Physics or equivalent qualifications. Experience in the following fields of development would be an advantage:— Domestic Radio or Television, Electronic Equipment for Aircraft, Communication Receivers, Pulse Circuits and Micro-Wave Techniques. Write giving full details and salary required to the Chief Engineer, Power Road, Chiswick, W.4. W 2955

CANADA NEEDS ELECTRONIC ENGINEERS. Measurement Engineering Ltd., with expanding business in Electronic Instrument field, offer generous salary, excellent prospects, to keen man capable of starting and taking charge of a section to handle Magnetic Amplifier Design. Applicants must be Physics or Engineering graduates with several years' industrial experience, including two years on magnetic amplifiers. The location is Ontario, within easy reach of Chalk River and Ottawa. Interviews London (England). Box No. W 1286.

CHEMISTS AND PHYSICISTS required for the preparation and evaluation of luminescent materials for use in a new project. Men of graduate standing with relevant experience are needed. Salary in accordance with qualifications. Location near Northampton. Box No. W 2855.

CHIEF MAINTENANCE ENGINEER required to direct a team working on Development Equipment associated with Trials Programmes on Radar Projects, and to work in association with development groups and services representatives. Applicant should preferably have had considerable experience of Radar Equipment and possess a Degree, Higher National Certificate or equivalent qualification. Residence in the Midlands is desirable but not essential and applicant must be prepared to travel occasionally. Reply stating age and experience to the Personnel Manager, The General Electric Co. Ltd. Brown's Lane, Allesley, Coventry. W 2943

COMPUTORS. Decca Radar Limited invite applications from Electronic Engineers and Mathematicians with an interest in Computor development and system engineering. The posts are permanent and a pensions scheme is in operation. Excellent starting salaries on a rising scale are available to successful applicants. The prospects of advancement are high. British Nationality essential. Reply to Research Director, Decca Radar Limited, 2 Tolworth Rise, Surbiton, Surrey. W 3028

DESIGN-DRAUGHTSMAN (Mechanical) for important, well-paid, pensionable position concerned with specialized production machines, including automatic, mechanized equipment. Machine-tool experience helpful but energy and initiative are principal qualifications. Apply in writing giving age and career details to Personnel Officer, Induction Heating Division, Birlec Limited, Tyburn Road, Birmingham 24. W 1288

DESIGNER DRAUGHTSMAN required for design and development of test gear to meet production demands of Thermionic Valves and Cathode Ray Tubes. Applicants should have good mechanical knowledge, with previous experience in mechanical and electrical interlocks, component layouts for Power Supply Units up to 50 KV 50 cycles and R.F. or Induction Heaters. Housing facilities available near factory area. Write stating age and full details of previous experience and technical training to The Edison Swan Electric Co. Ltd., Eastern Industrial Area, Harlow New Town, Essex. W 2972

DESIGNER DRAUGHTSMEN with sound experience of Presision Mechanical or Electro-Mechanical Equipment and holding the H.N.C. required on important work in the London area by Large Engineering Company. Salary in £600/£800 year range to successful applicants, together with a living allowance if coming from outside the district. Positions are permanent and Pensionable. Please write giving full particulars of experience and qualifications to Box No. W 1291.

DEVELOPMENT ENGINEER. Muirhead & Co. Ltd., Beckenham, Kent, have a vacancy for Physicist or Electrical Engineer (with degree or similar qualifications) on the development of data transmission devices, miniature motors and instrument servo mechanisms. Salary according to experience. Pension Scheme. Apply in writing to Personnel Manager. W 2994

DEVELOPMENT ENGINEERS with communication or electronic engineering qualifications and some practical experience are required for interesting work on cathode-ray oscillographs and associated equipment at our new Laboratories. Salaries £400-£800 depending on age and qualifications. Write giving full details to: Southern Instruments Ltd., Oscillograph Division, Camberley, Surrey. W 1245

DEVELOPMENT ENGINEERS. Qualified men with experience, interested in the design and development of domestic Radio and Television Equipment, are offered interesting and progressive work in this Field. Situated in Midlands. Applicants should write stating qualifications and experience to The Personnel Manager (Ref. GLB.) Box No. W 2770.

DEVELOPMENT ENGINEERS. The British Tabulating Machine Co. Ltd., Letchworth, Herts, manufacturers of Electro-mechanical and E'ectronic punched card accounting and statistical machinery, has vacancies for Graduate Engineers and men of H.N.C. Standard who have completed their National Service, on interesting Electro-Mechanical Design and Development work. Previous shop and design experience preferred. Salary according to experience and qualifications. Pension and Sick Pay Schemes are in operation. Write giving personal particulars to Personnel Officer. (ref. E628E). W 2926

DRAUGHTSMAN required for detailing mechanical and electrical assemblies. Must be capable of reading electronic circuits. Applicants with any previous experience on Sheet Metal Cubicles, H.V. Power Supply Units, Induction Heaters or Radio and Television layouts should write stating age and full details of previous experience and technical training. Housing facilities available near factory area. The Edison Swan Electric Co. Ltd., Eastern Industrial Area, Harlow New Town, Essex. W 2973

DRAUGHTSMEN. An expanding production programme has created a number of vacancies for Mechanical Designers, Senior Draughtsmen and Detail Draughtsmen. Situated in the Midlands. The work involves the complete engineering of electronic apparatus for Government Contracts and of domestic Radio and Television equipment. Applicants interested in this type of work, with or without experience, are invited to apply, giving details of career and salary expected to the Personnel Manager. (Ref.GLB) Box No. W 2996.

DRAUGHTSMEN experienced in Broadcast Radio and Television are offered exceptional opportunities with a firm of repute in the London area. Experience in Production Drawing or Mechanical Design would qualify for a very attractive starting salary. Applications, which will be treated in strict confidence, should give full details of experience and should be addressed to Box No. W 2969.

DRAUGHTSMEN: Vacancies for senior draughtsmen with experience of Electronic and/or Electro-mechanical engineering required, preferably with experience of Ministry requirements. Excellent prospects with good commencing salaries; non-contributory Pension Scheme in operation. Applications will be treated in strict confidence and should give full chronological details of qualifications, experience and age to: John A. Smith Ltd., 24 Lichfield Street, Wolverhampton. W 201

EDISON SWAN ELECTRIC COMPANY LIMITED, have a vacancy for an engineer to take charge of their Special Products' Development Laboratory. Candidates should have an Engineering Degree or its equivalent, and should have experience in developing electronic equipment ready for factory production. Please write full particulars, including age and salary required, to 155 Charing Cross Road, London, W.C.2. Reference K.S.P. W 184

ELECTRICAL/ELECTRONIC ENGINEER. Vickers-Armstrongs Limited, Supermarine Works, require for employment at their experimental Airfield, graduate with research and development experience in electronic and electromechanical devices and/or recording equipment for interesting work on ground and airborne measuring apparatus; the right man for this post will be keen to suggest and assess new techniques and to design and engineer suitable and workmanlike equipment. Permanent pensionable post with good prospects for suitable engineer. Apply Personnel Department, Hursley Park, Nr. Winchester. W 2856

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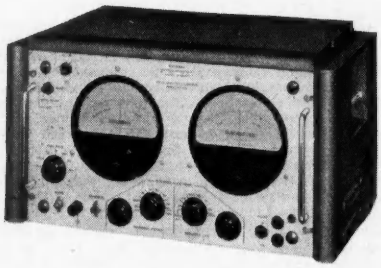
They're a little tied up

Robert the Bruce took a tip from the spider. When it comes to a tight-woven web, many of the little monsters could pick up an idea or two from Dr. Frittertime. Threading a tortuous path from project to project, his lightning switches of emphasis are the dismay of his staff, and cause some remarkable entanglements.

We at Solartron follow a different pattern—requirement, solution, construction. That's how we evolved the Phase Sensitive Voltmeter VP.250, designed to answer the needs of laboratories throughout the country. It will pay you to avoid entanglements and profit by our know-how.



BRIEF SPECIFICATION OF VP.250

Frequency Range :	20 c/s—20 Kc/s.
Accuracy of Indication :	Better than ± 2% of full scale on all ranges.
Voltage Ranges :	Reference : 15 mV—20 volts. Signal : 15 mV—15 volts in seven ranges.
Input Impedance :	Greater than 50 megohms in parallel with approximately 8 pF for both signal and reference input.
Noise and Harmonic Rejection :	Better than 40 db.

For full details, write to : Dept. E.4,

SOLARTRON ELECTRONIC GROUP LTD.

RELIABILITY—COSTS UNDER OUR 12 MONTHS' GUARANTEE HAVE NEVER EXCEEDED 0.2% OF SALES

Queen's Road, Thames Ditton, Surrey.
Telephone : Emberbrook 5611.
Cables : Solartron, Thames Ditton.

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

ELECTRICAL AND MECHANICAL ENGINEERS. Sunvic Controls Ltd. (a subsidiary of Metropolitan-Vickers Electrical Co. Ltd.) have the following vacancies in their new Development and Production Units at Harlow. 1. Graduate Engineer with experience in design or development of electro-mechanical mechanisms and their application to instrument problems. 2. Graduate engineer with practical experience in the development of electronic equipment and preferably a knowledge of the latest development in pulse techniques. 3. Application engineer of degree standard with experience in the application of electronic techniques to industrial and process control problems. The above positions are permanent and offer excellent prospects for promotion in a team engaged on the development and manufacture of a wide range of new instruments. Salaries will be according to age and ability. The Company's contributory pension scheme applies in all cases, and housing is available if required. Reply in writing, giving full particulars of age, experience, qualifications and present situation, to Chief Engineer, Sunvic Controls Ltd., Harlow, Essex. W 209

ELECTRICAL ENGINEERS OR PHYSICISTS who have qualified with a University Degree or Higher National Certificate are required for the Investigation of Radio Interference over a wide and interesting range of interfering sources. Applicants should write to the Director of Research, The British Thomson-Houston Co. Ltd., Rugby, giving their age and qualifications, quoting the Reference HI. W 2896

ELECTRICAL ENGINEER with design and development experience required by London Company manufacturing heating equipment for laboratory and industrial use. The applicant should have initiative and will be required to co-ordinate and guide the development of new products through all stages. To a man 30-40 years of age the position offers wide scope in a very interesting expanding field. Academic or professional qualifications and ability to control staff are necessary. The post is permanent with good prospects of advancement. Salary according to qualifications and experience. Apply in strictest confidence stating age, qualifications, experience and present remuneration to Box No. W 2951.

ELECTRICAL ENGINEERS, Senior and Junior, are urgently required for the Engine Controls Department of Smiths Aircraft Instruments Ltd. at Cheltenham. The work embraces Research and Development on automatic controls for aero gas turbines, magnetic amplifiers and electro mechanical control units. Applicants should have some experience of magnetic amplifiers, electronics, small electro-mechanical instruments or theoretical or practical aspects of servo mechanisms. The positions are permanent and carry generous salaries commensurate with experience and qualifications. A Pension Scheme is available. Applications with full details of qualifications, experience, and salary required, should be made to: Personnel Manager, Smiths Aircraft Instruments Ltd., Bishop's Cleeve, near Cheltenham, quoting reference 51/EN. W 1292

ELECTRICAL ENGINEERS. Graduates required for work associated with Automatic Control Systems. Work includes detailed design of control circuits and co-ordination of schemes. Knowledge of electronic and magnetic amplifier techniques an advantage. Vacancies also for those with specialized knowledge for development work on control systems. The posts are permanent and pensionable. Applicants must have completed or be exempt from National Service. Apply in writing, marking envelope "L1" to Personnel Manager, Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester 17. W 2934

ELECTRICAL RESEARCH ENGINEERS and Assistants are required in the Electrical Laboratories of C. A. Parsons & Co. Ltd., Heaton Works, Newcastle-on-Tyne, 6. Vacancies occur in Research Groups engaged in high voltage investigations, vibration and strain studies on heavy electrical machinery; and for an Electrical Engineer for testing of new electronic instruments and preparing instruction manuals. Applications for the posts of Research Engineer should possess a Degree or its equivalent in Electrical Engineering and for the post of Assistant possess the H.N.C., O.N.C., or its equivalent. Prior consideration will be given in each case to applicants who have completed a recognized engineering apprenticeship and have also completed their term of National Service. Good commencing salaries and excellent opportunities for advancement for men with initiative. Pension scheme in operation. Apply in writing, giving age and full chronological details of qualifications and experience to the Personnel Manager. W 2949

ELECTRONIC AND ELECTRICAL Designer/Draughtsman required with experience of wiring and electronic component requirements for electronic apparatus as used in industry. Apply stating qualifications, experience and salary required to Drawing Office Manager, Bailey Meters & Controls Ltd., Progress Way, Croydon. W 1284

ELECTRONIC ENGINEER required for design and development work on electronic measuring instruments. Experience in this field essential. Good salary and excellent prospects for advancement in expanding company. Rivlin Instruments Ltd., 7a Maitland Park Villas, N.W.3. W 1310

ELECTRONIC ENGINEER required for the expanding Electronic Section of a prominent food organization in N.W. London to construct and maintain factory electronic installations and to assist in the development of new equipment. Applicants should possess initiative and be below 35 years of age. Salary according to age and experience. Pension Scheme; 5-day week. Write Box E.E.908 c/o 191 Gresham House, E.C.2. W 2939

ELECTRONIC ENGINEER required by London firm to take charge of measurements laboratory and test gear design. Experience of measurements of capacitors or telecommunication cables is essential. Position involves direct responsibility to managements and will suit engineer aged 25 to 32 who wishes to take up senior position. Write details of qualifications, experience and present salary. Box No. W 186.

ELECTRONIC ENGINEER required for Senior position in an expanding laboratory engaged on the development of electronic equipment including control gear, servo-mechanisms and special purpose tape recorders. Applicants should state qualifications, experience and salary required. Write full details to Box No. W 1289.

ELECTRONIC ENGINEER. Unique opportunity for young man with vision, suitable technical qualifications and experience. Age range 25-30. Project covers application of a metal detecting technique for use in the industrial and allied fields. Ability to conduct technical selling a necessity and some commercial knowledge desirable. Only individuals of character and those fitted for pioneer work involving some travel at home and abroad should apply for an opening possessing unusual scope for initiative and personal development. Box No. W 1307.

ELECTRONIC ENGINEER required for exceptionally interesting development work. Applicants should have good academic training with 5-10 years' practical experience of development including some on communication equipment emp'oying frequency modulation at U.H.F. The post carries a good starting salary and excellent prospects. Please write, with details to Personnel Dept. (ED/189) E.M.I. Eng. Dev. Ltd., Hayes, Middlesex. W 3005

ELECTRONIC ENGINEERS. Young engineers, possessing initiative and a desire for responsibility, and technical training up to Degree standard (Physics or Electrical Engineering), are required to assist in the development and testing of Guided Weapon Control Systems. Some experience of the design and use of analogue computers desirable but not essential Good salary and bonus. Pension Scheme. Apply, quoting ref. EE/58 to the Assistant Manager, The Fairey Aviation Co. Ltd., Weapon Division, Heston Aerodrome, Hounslow, Middlesex. W 2942

ELECTRONIC ENGINEERS are required by the English Electric Co. Ltd., to fill vacancies in the Company's Laboratories at Luton and Stevenage. 1. Senior Micro-wave Engineer—applicant should have a good theoretical background to degree standard and experience of design or engineering of microwave equipment. The work includes investigation of new methods of construction with a view to miniaturization and weight reduction. 2. Senior Engineer—to lead a group of engineers in the development of specialized electronic test gear. 3. Senior Engineer—for work on general circuit development, with sound fundamental knowledge of electronics and the ability to apply it. 4. Senior Instrumentation Engineers—with a degree or H.N.C. and experience of the design of equipment for use in the instrumentation field. 5. Senior Engineer—to lead a group concerned with development and field trials of ground radar. Previous experience essential. 6. Senior Radar and Electronic Engineers—for development and field and flight experiments of radar equipment. Degree or H.N.C. standard preferred but applicants without these qualifications but with wide experience of this work considered. 7. Senior Engineer—for missile telemetry installation planning. Applicants must be familiar with existing telemetry systems and measuring techniques, suitable to a man with trial experience. 8. Junior Engineers and Laboratory Assistants—are required to assist in the above work. Vacancies also exist for Junior staff with experience of, or an interest in Microwaves. Housing assistance may be given in some cases. All of the above posts are permanent and progressive and pensionable after qualifying period, attractive salaries are offered to the successful applicants. Applications should be sent to Dept. C.P.S., 336/7 Strand, W.C.2, quoting ref. number 1260B. W 3027

ELECTRONIC ENGINEERS with degrees in physics or engineering required for important and interesting work on the research and development of special equipment. Good opportunity and high salary rate. Write to Managing Director, Microcell Ltd., 56 Kingsway, London, W.C.2. W 2993

ELECTRONIC ENGINEERS. A development section for work on Government contracts is to be created at a new, modern and attractively situated G.E.C. factory. There are posts of varying responsibility requiring men with practical Electronic Development experience and with qualifications ranging from H.N. Cert. to Hons. Degree. Applications, which will be treated in strict confidence, should be detailed and addressed to Personnel Manager, S.E.I. Limited, School Street, Hazel Grove, Cheshire. W 3002

E.M.I. ENGINEERING Development Ltd. Commercial Electronics. Exceptionally interesting vacancy exists for a Development Engineer in a team designing automatic control system for application to machine tools. Applicants should have a thorough engineering training with an interest and experience in servo systems and their design. The post carries good starting salary and opportunity for initiative. Please write in confidence, with full details, to Personnel Dept. (ED/224) E.M.I. Eng. Dev. Ltd., Hayes, Middlesex. W 2927

E.M.I. ENGINEERING DEVELOPMENT LTD. Computer Engineers. Applications are invited from Senior and Junior Electronic Engineers with experience in the design of digital computors to take part in a large scale development programme for Commercial Accounting Systems. The posts carry good starting salaries and outstanding opportunities. Vacancies also exist for Assistant Programmers. Applicants should write in confidence, with full details to Personnel Dept. (ED/226) E.M.I. Eng. Dev. Ltd., Hayes, Middlesex. W 2937

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

E.M.I. ENGINEERING DEVELOPMENT LTD. Commercial electronics. Exceptionally interesting vacancy exists for a development Engineer in a team designing automatic control system for application to machine tools. Applicants should have a thorough engineering training with an interest and experience in servo systems and their design. The post carries good starting salary and opportunity for initiative. Please write in confidence, with full details, to Personnel Department, (ED/224), E.M.I. Eng. Dev. Ltd., Hayes, Middlesex. W 3006

E.M.I. ENGINEERING DEVELOPMENT LTD. Computor Engineers. Applications are invited from Senior and Junior Electronic Engineers with experience in the design of digital computors to take part in a large scale development programme for Commercial Accounting Systems. The posts carry good starting salaries and outstanding opportunities. Vacancies also exist for Assistant Programmers. Applicants should write in confidence, with full details to Personnel Dept. (ED/226), E.M.I. Eng. Dev. Ltd., Hayes, Middlesex. W 3007

ELLIOTT BROS. (LONDON) LIMITED have vacancies for Senior and Junior Electronic Engineers in their expanding activities in the fields of industrial control, measurements and instrumentation. Senior Engineers with good academic background and experience in this or similar fields. There is one vacancy for a Chief Engineer to take charge of a Division and several vacancies for leaders of development teams. Ref: E.T.1. Junior Engineers with University Degree and 2-3 years' practical experience to work under the guidance of seniors in development teams. Ref: E.T.2. Laboratory Assistants with H.N.C. or equivalent and with interest to further their education and experience and train as development engineers. Ref: E.T.3. Applications for the above positions with full details of age, qualifications and experience and quoting the appropriate reference number, to Personnel Officer, Century Works, Lewisham, S.E.13. W 2938

ENGINEERS 25-30 required for electronic and mechanical work by The Plessey Company Limited at Ilford. Good prospects of promotion, interesting work and a pension scheme await suitably qualified graduates or holders of H.N.C. Apply with full details of past experience to The Plessey Company Limited, Vicarage Lane, Ilford. W 2985

ENGINEERS AND PHYSICISTS with a Degree or H.N.C. are required for permanent posts in the Guided Weapons Division of The English Electric Company Limited at Luton, for work on analogue computors and simulators. In particular a Senior Man is required to supervise the design and construction of a large general purpose computor, and there are Junior Posts connected with this project and others allied to it. Applicants should preferably have design experience in analogue computing or related fields such as servo-mechanisms and negative feedback systems. Applications to Dept. C.P.S., 336/7 Strand, W.C.2, quoting Ref. S.A.50C. W 2977

ENGLISH ELECTRIC VALVE CO. LTD., Chelmsford. Junior Engineers required for Valve Development Work, especially on the application of microwave valves to circuitry. Applicants should have a Degree and preferably some experience in microwave technique or alternatively with amateur transmitters. Apply, quoting Ref. 497M. to Dept. C.P.S., 336/7 Strand, W.C.2. W 2976

ENGINEERS AND DRAUGHTSMEN: Excellent opportunities for keen and enthusiastic engineers and draughtsmen for a wide variety of work associated with Radio and Machine Frequency, Resistance Heating Development, and Application problems. The posts are permanent and pensionable, and every opportunity for advancement is available. Salary will be in accordance with age, experience and qualifications. Engineers for development and design of Radio Frequency Generators. Applicants must have had a full time electrical apprenticeship and experience in high power R.F. equipment. Qualifications—H.N.C. or full time University Degree. Engineers for development and design of Mechanical Handling Equipment associated with Radio and Machine Frequency Heating Applications. Applicants must have had a full electrical or mechanical apprenticeship and experience in the design of Mechanical Handling Equipment, including pneumatics and hydraulics. Qualifications—H.N.C. or full time University Degree. Technical Assistants and Junior Engineers for Experimental Laboratory work on problems related to the application of Radio, Machine Frequencies, and Resistance Heating. Candidates must have had a full time electrical or mechanical apprenticeship and reached at least O.N.C. standard. Draughtsmen, Seniors and Juniors for circuitry layouts, mechanical and electrical equipment associated with Radio, Machine Frequency, and Resistance Heating Applications. Candidates must have had a full electrical or mechanical apprenticeship and have O.N.C. or H.N.C. in electrical or mechanical engineering. Write for application form to: The Personnel Manager, Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17, marking envelope "R.I". W 3050

ENGINEER with electrical or physicist Degree required for development work on testing equipment for telecommunication cables. Permanent and pensionable position at salary commensurate with experience and qualifications. please apply giving full particulars to Personnel Officer, Southern United Telephone Cables Ltd., Dagenham Dock, Essex. W 1300

ERICSSON TELEPHONES LTD. have in their Research Laboratories a number of vacancies for circuit designers and equipment engineers to work on nucleonic instruments, and interesting new developments in electronic computing and switching; both senior and junior posts are available. Applicants should have a degree or equivalent plus several years' experience of appropriate work for the senior posts; correspondingly reduced qualifications and experience will be accepted for junior posts. Salaries will be in accordance with age, qualifications and experience. Applications, giving details of age, academic or other training and qualifications, experience, and starting salary required, should be sent to the Personnel Officer, Ericsson Telephones Ltd., Beeston, Nottingham. W 197

ESTIMATING ENGINEER required in expanding organization. Applicants should be between 35/40 years of age, have a H.N.C. in mechanical or production engineering, and preferably have experience of the telephone or electronic industry. Apply Personnel Officer, Airmec Ltd., High Wycombe, Bucks. W 2911

EXPERIENCED Radio Testers and Inspectors required for production of communication and radio apparatus. Also Instrument makers, wirer and assemblers for Factory Test apparatus. Apply Personnel Manager, E. K. Cole Ltd., Ekco Works, Malmesbury, Wilts. W 146

FERRANTI LTD. (Moston) Manchester, have vacancies for Test Engineers to undertake work under the following headings: 1. General testing and fault finding on electronic and servo units. 2. Advanced testing of above units in final forms as analogue computors. 3. General testing of electronic testing outfits. (This will mainly involve electrical measurements.) 4. General testing and fault finding on gyroscopic instruments. 5. Design, development and maintenance of test equipment for electronics, servos and gyroscopes. Knowledge of general power supplies would be an advantage. A standard of approximately H.N.C. is desirable but lesser qualifications would be acceptable if combined with practical ability and experience of this or analogous work (e.g., in H.M. Forces). Permanent Staff appointments with Pension benefits. Application forms from Mr. T. J. Lunt, Staff Manager, Ferranti Ltd., Hollinwood, Lancs. Please quote reference HGN. W 3035

FERRANTI LTD., (Electronics Dept.) Manchester have the following vacancies at their Moston, Chadderton and Wythenshawe factories:— 1. Chief Planning Engineer for Cathode Ray Tube production. The essential qualification is previous responsibility and experience in planning and progress, preferably, though not necessarily, in C.R.T. manufacture. 2. Process Control Engineers with considerable experience of C.R.T. production and of the technical problems involved. 3. Technical Maintenance Engineer with experience of vacuum equipment and automatic and mechanical apparatus of the type used in C.R.T. production. Knowledge of electronic circuitry would be an advantage. 4. Plant Engineer. A young mechanical engineer, preferably with some knowledge of vacuum or chemical techniques is required to assist in the design of automatic plant for C.R.T. and valve production. 5. Circuit Engineer for work with new types of valves including the design of circuitry for use with them. The successful candidate would also assist the Sales Department in establishing these new types. 6. Valve Design Engineers holding good Honours Degrees in Physics or Electrical Engineering and preferably with previous experience of Valve design. 7. Circuit Engineer for a Ceramic Valve Laboratory, having experience of R.F. work and preferably of pulse circuitry. He would be required to determine the characteristics of advanced types of valves opening up new and interesting fields. Salaries would depend on age and experience within the following ranges:— Post 1—£800-£1,000 per annum. Posts 2, 4, 5, 6, and 7—£600-£900 per annum. Post 3—£500-£700 per annum. Permanent staff appointments with Pension benefits. Application forms from Mr. T. J. Lunt, Staff Manager, Ferranti Ltd., Hollinwood, Lancs. Please quote reference PDH 1, 2, 3, 4, 5, 6, or 7. W 2984

FERRANTI LIMITED, EDINBURGH. Graduate Engineers are required for the design and manufacture of Radar and Fire Control Systems. The work involves all aspects from system study, component and general design and flight trials to production. The Instrument and Fire Control Division particularly require Graduate Engineers interested in the design and development of Magnetic Amplifiers; Analogue Computors; Electronic Circuits for these systems. Previous experience in this class of work is desirable. There are also vacancies for experienced men with Higher National Certificate, or similar qualifications. Apply, giving full particulars of academic training and experience, quoting Ref. 23/G/I/L, to the Personnel Officer, Ferranti Limited, Ferry Road, Edinburgh, 5. W 3024

SITUATIONS VACANT (Cont'd.)

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

FERRANTI LIMITED, EDINBURGH—Flight Trials Division. Applications are invited for Electronic Engineer for interesting work in their Flight Trials Division. The engineer will be engaged on trials to evaluate the technical and operational performance of fire control and navigational systems, air and ground. The qualifications required are to degree or equivalent standard with a minimum of three years' experience. Ref. No. EE/TID. Radar Maintenance Engineer who will be responsible for a small outstation. Duties will involve limited travelling in the U.K. Ref. No. RME/TID. Ex-Radar Officers and Senior N.C.O.s are invited to apply for either or both vacancies. The appointments are pensionable and offer excellent prospects and working conditions in or attached to our new laboratories. Apply for an application form, quoting appropriate reference number, to the Personnel Officer, Ferranti Limited, Ferry Road, Edinburgh, 5. W 2679

FIRST-CLASS openings for experienced Radio and Television Engineers will shortly become available with a firm of repute in the London area. Engineers able to undertake immediately development work on Broadcast Radio and Television Apparatus would be offered an attractive salary. The successful candidates will be eligible for Company Superannuation and Insurance Schemes. Please reply, giving full details of experience to Box No. W 2970.

GRADUATES, with and without experience are invited to apply for interesting and progressive positions in the Research Laboratories of a large manufacturing organization. Vacancies in the following fields are offered to suitable applicants. The overall performance of communication systems of all types. Centimetric research, micro-wave links and associated equipment and problems. Transistor development and applications. Circuit development for telecommunications and television. Applications for interview should be made to:—Mr. P. J. Rogers, Personnel Manager, Standard Telecommunication Laboratories Limited, Progress Way, Great Cambridge Road, Enfield, Middlesex. W 2950

GRADUATE PHYSICISTS are required by the Nelson Research Laboratories, Stafford, for experimental work on a variety of problems in the field of vacuum electronics. Preference given to applicants with post-graduate experience. Please apply to Dept. C.P.S., 336/7 Strand, W.C.2, quoting Ref. 308E. W 2978

GUIDED WEAPONS: Design Engineers—Technicians. The Guided Weapons Department of the Bristol Aeroplane Company Limited, at Filton, requires to recruit the following:— 1. Design Engineer: to design and develop D.C. and L.F. circuitry for use in computing and other servo applications. A Degree in electrical Engineering or an equivalent professional qualification is desirable. 2. Technical Assistant: To service electronic-servo test equipment. Considerable practical experience, a high standard of education and a sense of responsibility are essential requirements. Applications, quoting D.O.35, giving details of age, experience, and salary required, should be addressed to the Personnel Manager, Aircraft Division, Bristol Aeroplane Company Limited, Filton House, Bristol. W 2986

HATFIELD INSTRUMENTS LTD., who are now expanding their laboratories require senior and junior electronic engineers with experience in the design and test of high grade Radio and Industrial Laboratory Equipment. Apply in writing in the first instance stating age, experience and salary required to Hatfield Instruments Ltd., 175 Uxbridge Road, Hanwell, W.7. W 3038

HIVAC LIMITED, Manufacturers of specialized thermionic and electronic devices, offer interesting posts for scientists, engineers and technicians in their existing organization on research and development projects in valves, cold cathode tubes and transistors. Previous experience in these fields, though an advantage, is not essential, but a sound education and an active and inquiring mind are. Encouragement will be given, wherever possible, to the publication of original work. The Company is a member of a major communications Group and the posts, which are available for both senior and junior applicants, are pensionable and offer scope for advancement. There is a five-day working week. Applications in writing, which will be treated in strict confidence, stating age, education, qualifications and salary expected, should be addressed to The Engineer-in-Chief, Hivac Limited, Greenhill Crescent, Harrow, Middlesex. W 3025

IBM UNITED KINGDOM LTD. requires Senior Engineer to head new London laboratory. Applicants must have University Degree, recent experience in design of Electronic Digital Computors, and administrative ability. Apply in writing, stating qualifications, to: E. D. Swann, IBM United Kingdom Ltd., 100 Wigmore Street, London, W.1. W 1290

IMPERIAL CHEMICAL INDUSTRIES LIMITED, Nobel Division, requires Assistant Technical Officers in the Physics Research Section, Stevenston, Ayrshire. Candidates should have a Pass Degree in Science, or its equivalent, and preference will be given to those with experience of electronics. Application should be made in writing to the Staff Manager, 460 Sauchiehall Street, Glasgow, C.2. W 2987

IMPERIAL CHEMICAL INDUSTRIES LIMITED, Metals Division, has a vacancy for a Technical Officer for development work on special instrumentation for plant purposes. The work includes development of non-destructive testing equipment and its application, servo control and the use of process analysis techniques. Candidates should possess an Honours Degree in Physics or Electrical Engineering. Application forms may be obtained from Assistant Staff Manager, I.C.I. Metals Division, Kynoch Works, Witton, Birmingham, 6, quoting ENG/13. W 3000

IMPORTANT VACANCIES for Electrical Engineers for Guided Weapon Test Equipment. The following electrical engineers are required to develop and/or use electronics and electro-mechanical test gear:—Electrical Engineer (ref. E.E./46) to lead a small test and fault finding team. Applicants should have electronic experience, preferably in one or more of these fields:— servo-mechanisms, analogue computors, radar, micro-wave, pulse, communication or telemetry. Degree or H.N.C. standard essential. Development Engineer (ref. E.E./48). Young graduate required to design and develop electronic and pneumatic test equipment. Honours electrical engineering Degree essential. Assistant Engineer (ref. E.E./49) to compile inspection test instructions for component and missile testing. H.N.C. standard and electronic experience essential. These interesting appointments offer scope for advancement together with good salary and bonus. Pension Scheme. Send details of experience and qualifications, quoting appropriate reference, to the Assistant Manager, The Fairey Aviation Co. Ltd., Weapon Division, Heston Aerodrome, Hounslow, Middlesex. W 2961

J. LYONS & CO. LTD. have vacancies for both Junior and Senior graduates in electrical engineering or physics for training as systems maintenance engineers on electronic digital computers. Successful candidates will receive training in computer techniques on LEO I and will be transferred later to more advanced work on LEO II, now under development. Apply Control Office, Cadby Hall, W.14 W 2940

JUNIOR ELECTRONIC ENGINEER required for development work on electronic measuring instruments. Good salary and excellent prospects for advancement in expanding company. Rivlin Instruments Ltd., 7a Maitland Park Villas, N.W.3. W 1309

JUNIOR ENGINEERS required in departments covering the design and construction of high-grade television transmission equipment and a wide range of electronic equipment. Good fundamental knowledge required and some practical commercial experience desirable. Pension Scheme. Five-day week. Good Canteen. Write stating age, experience and salary required to Cinema-Television Limited, Worsley Bridge Road, Lower Sydenham, S.E.26. W 2991

LABORATORY ASSISTANT required for test and calibration of wireless, radar, electronic measuring instruments. Should be capable of setting up basic calibration and experimental equipment. Five-day week. Write or phone Atkins Laboratories, Gowan Avenue, Fulham. RENown 5931. W 1301

LABORATORY TECHNICIAN required for the Electrical Engineering Department for work in the electronics field. Commencing salary according to age and experience, in the scale £315×£15—£450 plus London Weighting (max. £30). The successful applicant must join the contributory pension scheme. Application, giving age and full details of experience, to the Secretary, King's College, Strand, W.C.2. W 2936

MANAGER for large electronic Company in N. London. Experience of mass production and small batch production of coils and transformers, etc. for radio, television and radar equipment. Control of 300 employees. Good Salary and prospects. Pension scheme, etc. Age 35-55. Write Box No. W 2960.

McMICHAEL RADIO LTD., Slough, Bucks, have vacancies from time to time for Electronic Engineers to be engaged on Government projects. Those wishing to be considered are invited to write fully to the Chief Engineer, Equipment Division. W 205

METROPOLITAN-VICKERS ELECTRICAL CO. LTD., Trafford Park, Manchester 17, have vacancies for servo engineers with some practical experience in Electric servo and control circuit design and application. Qualifications required, a Degree or Higher National Certificate. Applicants should not be less than 26 years of age. The posts are permanent and pensionable. Salary according to qualifications and experience. Apply in writing to The Personnel Manager, marking envelope "Servo Mechanisms." W 2557

MURPHY RADIO LIMITED have vacancies in the Electronics Division Laboratories for qualified engineers to design and develop the following: 1. V.H.F. and U.H.F. Communications equipment. 2. Airborne and Ground radar equipment. 3. Computing devices and servo systems. 4. Nucleonic equipment and measuring instruments. 5. Transistors and associated circuitry. The salary range is £600-£1,000 per annum depending upon experience. Further posts are available to engineers of H.N.C. standard or equivalent having less experience, the salary range being £450 to £650 per annum. These vacancies are at Welwyn Garden City but one or two vacancies of a similar nature are available at the Ruislip Works. Applications, giving age, full details of qualifications, experience and salary required, should be forwarded to Personnel Department, Murphy Radio Limited, Welwyn Garden City. W 2757

MULLARD RESEARCH LABORATORIES have vacancies for several Technical Assistants to be trained, at full salary, as Microwave Valve Engineers. Successful candidates will be engaged upon the design, construction and electrical measurement of valves in the research and development stages. The positions are permanent, progressive and carry attractive salaries. Applicants, without National Service liabilities, should have scientific qualifications of, or equivalent to G.C.E. (advanced level), O.N.C., H.N.C. However, these requirements might be waived if the applicant has experience in a suitable technical field. Salaries are based on qualifications, experience and age, and are in keeping with present-day levels. General prospects within the organiza-

SITUATIONS VACANT (Cont'd.)

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

tion are excellent. Apply Personnel Manager, Mullard Research Laboratories, Cross Oak Lane, Salfords, Near Redhill, Surrey. W 2872

MULLARD RESEARCH LABORATORIES require Electronic Engineer(s) for interesting design and development work on laboratory instruments and test equipment. Applicants must be capable of working on their own initiative and should have academic qualifications ranging from City and Guilds Final Certificate or 4th year National Certificate (Radio) to Degree standard. Several years experience in electronics is desirable and a good knowledge of pulse techniques is preferred. The positions offered are permanent, progressive and carry attractive salaries. Applications should in the first instance be addressed to the Personnel Officer, Mr. G. A. Taylor, Mullard Research Laboratories, Cross Oak Lane, Salfords, near Redhill, Surrey, quoting reference VPL (C). W 2911

MULLARD RESEARCH LABORATORIES in Surrey have a number of vacancies for Physicists and Electronic Engineers with a good Degree or equivalent qualification for work in a variety of projects including: (1) Solid Physics and Semi-Conductors. (2) Magnetic Materials and applications. (3) Microwave techniques. (4) Advanced Electronic circuit techniques, including Transistor applications. (5) Colour Television. (6) Computers and Servo-Mechanisms. Some years experience in one or more of these fields is desirable, but recent and prospective graduates are also invited to apply. Mathematics graduates with experimental leanings are not excluded. Successful applicants will join teams engaged on research and advanced development projects. Publication of original work wherever possible is encouraged. Salaries are based on qualifications, experience and age, and are in keeping with present-day levels. General prospects within the organization are excellent. Apply to Personnel Officer, Mullard Research Laboratories, Cross Oak Lane, Salfords, near Redhill, Surrey, quoting reference E.R.L. W 2916

NELSON RESEARCH LABORATORIES. English Electric Co. Ltd., Stafford, have a vacancy for a Physicist having an interest in solid state physics and electronics, to work on the fundamental properties and applications of materials suitable for use in electronic storage devices. An Honours Degree and some research experience are desirable. Salary at present-day levels in accordance with age and qualifications. Please reply to Dept. C.P.S., 336/7 Strand, W.C.2, quoting Ref. 1353B. W 2979

ONE OR TWO RESEARCH ENGINEERS are required by The English Electric Co. Ltd., at their Guided Weapons Division at Luton for extended studies into miniature high speed turbines and pumps, hydraulic servo systems and their associated control valves. The suitable men should be well qualified in mechanical engineering but an ability for original thought, and to work without supervision is of paramount importance. Salaries will be generous to the right applicants and housing assistance is possible. These posts offer excellent prospects for original work for which every facility will be offered. Applications to Dept. C.P.S., 336/7 Strand, W.C.2, quoting Ref. 1181D. W 3023

NELSON RESEARCH LABORATORIES. English Electric Co. Limited, Stafford, have vacancies for Assistants in interesting work on the Physics, development and applications of magnetic and electrical insulating materials and devices. Graduates with or without industrial experience and people with National Certificates in Electrical Engineering or Physics are required. Reply to Dept. C.P.S., 336/7 Strand, W.C.2, quoting Ref. 312A. W 2980

OPPORTUNITIES IN THE UNITED STATES for English-Trained Electronics Engineers. The Engineering Department, Electronics Division, of Westinghouse Electric Corporation has available a number of attractive situations to augment the engineers hired in England during 1953. Applicants must have professional standing in the Institute of Electrical Engineers or equivalent standing in the Institute of Radio Engineers. Applicants for these positions should be over 25 years of age with at least three years' experience in design or development in one or more of the following fields:— Circuitry, Antennas, Ground Radar, Microwave Cavities and Plumbing, Communications, Missile Guildance Equipment, Computors, Navigation Aids, Filters. Plant is located in the outskirts of Baltimore, Maryland, in the beautiful Chesapeake Bay area with splendid facilities for fishing and sailing. The mountains are but one and a half hours' drive away. Modern centrally-heated flats in suburban surroundings are readily available. Many opportunities for advanced education and for cultural pursuits are readily available in the Baltimore area. Generous relocation allowance is provided to help defray engineers' and their dependents' travel and shipping expenses. To arrange for interviews in Britain at an early date with the Manager of the Electronics Division Engineering Department address inquiry for application form to Mr. F. S. Mabry, Westinghouse Electric International Company, 1-3 Regent Street, London, S.W.1. All replies will be treated as confidential. W 2947

PHILIPS BALHAM WORKS LTD., 45 Nightingale Lane, S.W.12, requires Graduate in Electrical Engineering or Physics preferably with experience in electronics for development of nucleonic instruments. Permanent appointment with excellent prospects. Applications should be addressed to The Personnel Officer, at the above address. W 2915

PHYSICIST REQUIRED by modern expanding instrument company. A new division is being formed to deal with problems of industrial measurement and control; the work will appeal to a man deeply interested in the principles of precision measurement. Electrical and electronic methods are involved and some experience of these is necessary. A man of not more than about 25 is wanted; the initial salary will be fair and the prospects are excellent, but the first thought of any applicant should be whether he will enjoy the work. Please write to Dr. D. H. Parnum, Industrial Division, Southern Instruments Ltd., Frimley Road, Camberley, Surrey. W 3018

PROJECT ENGINEERS are required to take charge of Microwave Electronic and Mechanical developments in connexion with guided weapon and other applications in a company near London. Candidates should be graduates or hold H.N.C. and be between the ages of 30 and 40. Salaries range from £1,000 upwards according to age and experience. Pension Scheme in operation. Full particulars of experience should be addressed in confidence to Box No. W 3057.

RADIO ENGINEER for Bulawayo, Southern Rhodesia. Design and Development Engineer with at least five years' experience on domestic radio. Salary £1,200 per annum, with free air passage to Rhodesia. Application should be made to Advertiser, 31 Burlington Avenue, Kew Gardens, Surrey, with copy to P.O. Box 2096, Bulawayo, Southern Rhodesia. Successful applicant will be interviewed in London. W 1251

RADIO & TELEVISION ENGINEERS. First-class openings for an Experienced Car Radio Engineer, Television Engineers and Senior Design Draughtsmen, will shortly become available with a firm of repute in the London area. Engineers able to undertake immediately development work on Broadcast Radio and Television Apparatus would be offered an attractive salary. The successful candidates will be eligible for Company Superannuation and Insurance Schemes. Please reply, giving full details of experience to Box No. W 2968.

R. B. PULLIN & CO. LTD. invite experienced Electronic Engineers to apply for a vacant post in the Company's Electronic Development Division. Applicants should possess an honours degree or equivalent qualifications, and should have had several years' experience of the development of electronic circuits, preferably including work on electrical servos and magnetic amplifiers. The post is of a senior and permanent nature; it offers excellent prospects in a recently created and expanding laboratory, and the work calls for a high degree of individual technical responsibility and initiative. A commensurate salary will be paid. Contributory pension scheme, canteen and recreational facilities. Applications will be treated as confidential, and should be made in writing stating full details to the Superintendent, Electronic Development Division, R. B. Pullin & Co. Ltd., Phoenix Works, Great West Road, Brentford, Middlesex. W 3003

RESEARCH AND DEVELOPMENT ENGINEERS are required for work on Electronic Switching, Computing and Control Apparatus. Applicants should preferably have had experience of one or more of the above. A good university degree in engineering or physics would be an advantage. Further vacancies exist for Junior Engineers and Technical Assistants. Excellent opportunities for advancement to more senior positions. Starting salary, according to qualifications and experience, will be in the range of £400 to £1,100 per annum. The Company operates a Superannuation Scheme and offers attractive working conditions with generous holiday and leave arrangements, and good social and recreational facilities. All applications will be dealt with in confidence and should be addressed to the Director of Research, British Telecommunications Research Ltd., Taplow Court, Taplow, Bucks. W 2957

RESEARCH ASSISTANT (male) required for research on the reactions of fish to water at different temperatures. Work (in London) includes development, operation and maintenance of electrical and photographic recording apparatus. Degree in mathematics or science preferred; practical knowledge of electricity required. Salary of Assistant Experimental Officer starting, according to age and qualifications, between £290 and £520; pension scheme. Applications with particulars, education, qualifications, National Service, experience, and addresses of two referees to the Director, Freshwater Biological Association, The Ferry House, Far Sawrey, Ambleside, Westmorland, by 15th May. W 1308

RESEARCH ENGINEERS — preferably of Degree standard, and with a sound knowledge of communications and, particularly electronics required for experimental work relating to underwater sound apparatus. Applications giving past experience, technical qualifications, age and salary required, should be addressed to the Personnel Manager, Kelvin & Hughes Ltd., New North Road, Barkingside, Ilford, Essex. W 2958

RESISTANCE WELDING RESEARCH. Senior investigator required to take charge of resistance welding laboratory. Degree essential, preferably in electrical engineering; knowledge of electronics an advantage. Position will carry grade of Senior Research Officer (£700-£1,150 p.a.) and will qualify for membership of superannuation scheme (F.S.S.U.). Starting salary according to qualifications and experience.

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

Apply in writing: Chief Administration Officer, British Welding Research Association, Abington Hall, Abington, Cambs. W 1271

REQUIRED. Senior Electronic or Electro Mechanical Draughtsmen preferably with experience of IDP.13 and RCS.1000. Draughtsmen applicants not possessing experience of these standards will be considered for training. Also female Tracers required who have had experience on mechanical and electronic work. Offices situated in Mayfair. Box No. W 1306.

SALES MANAGER to handle specialized engineering production equipment. Progressive position with good status, salary and pension, involving responsible personal contacting and technical correspondence with automobile and related industries. Personality, energy and initiative more important than long experience. Apply in writing with details of education and career to Personnel Officer, Induction Heating Division, Birlec Limited, Tyburn Road, Birmingham, 24. W 1287

SECTION LEADER DESIGN DRAUGHTSMAN in West End (London) drawing office. Senior staff status. Pension Fund and Life Insurance. Real opportunity for advancement to ambitious man with energy and drive. Minimum qualifications apprenticeship and H.N.C. or equivalent, with 5 years' subsequent experience, aged 24/45. Preference given to men with knowledge of aircraft industry on light electrical, electronic or instrument work. Please write in detail, or send postcard for Form of application, quoting Ref. 126 to The Personnel Manager (Technical Employment), de Havilland Propellers Ltd., Hatfield, Herts. W 2997

SENIOR & JUNIOR Design Draughtsmen required for interesting work in connexion with electronic equipment, commercial radio and television and/or light electro-mechanical engineering. London area. The positions vacant offer ample scope and opportunity for future advancement to men of good ability. A high salary will be paid to the selected candidates. All recognized staff privileges available. Please reply, giving full details of experience to Box No. W 2917.

SENIOR AND JUNIOR Development Engineers required for responsible work in Radio and Television Development Laboratories. Applicants for senior position should be able to undertake development work with minimum supervision. Excellent conditions and salary available for applicants who are accepted. Apply in first case to Personnel Manager (Dept. R.D.), McMichael Radio Ltd., Wexham Road, Slough, Bucks. W 2671

SENIOR AND JUNIOR RESEARCH PHYSICISTS preferably with University or Industrial Research experience are required to undertake basic research work on Thermionic Emission and related aspects of service physics. Wide scope and good prospects for men with initiative. Applicants should write to the Manager, Research Department, Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17, giving particulars of their age, qualifications and experience and suitable references. W 2883

SENIOR SALES ENGINEER required by Telephone Manufacturing Co. Ltd., Martell Road, West Dulwich, London, S.E.21 with a minimum of 10 years' qualified experience. Must have comprehensive knowledge of the use of polarized relays in telecommunications, servomechanisms, electronic circuits and allied applications. Pension and Staff Bonus Scheme after qualifying period. Write giving full particulars to Personnel Department. W 2959

SENIOR MECHANICAL DRAUGHTSMEN required for Radar and Electronics. Modern D.O. with first rate conditions, salaries according to experience. Previous experience in Electronics not essential. Apply in writing to Chief Draughtsman, Radio Department, Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17. W 2891

SENIOR DESIGN DRAUGHTSMEN required by a large engineering company due to expansion of the Company's services and commercial business. Applicants should have a comprehensive knowledge of mass production of radio, television and electronic equipment. Salary up to £700 per annum, monthly status. The vacancies are of a permanent and progressive nature. Company's superannuation and life assurance schemes in operation. Please reply giving details of experience to Box No. W 2918.

SENIOR ENGINEERS, JUNIOR ENGINEERS TECHNICAL ASSISTANTS are invited to apply for positions where energy, initiative and skill will be well rewarded. The work relates to the development of television circuits, and the design of components for large scale production. Experience of television receiver design is required in respect to means of scanning and focusing or the design of R.F. and I.F. circuits. The positions are permanent ones which offer scope for advancement to senior positions. The commencing salary will be in accordance with experience, based on a generous and progressive scale. Write giving full personal particulars to the Personnel Manager, The Plessey Company Limited, Ilford, Essex. W 3010

SENIOR PROJECT ENGINEER. A vacancy is available for a Senior Project Engineer to head a group for the production of power from atomic energy. Applicants should have a background of experience, preferably in marine engineering or, alternatively, experience on the mechanical side of the generation of power for land purposes. In addition, applicants should have scientific qualifications in the form of First-Class Honours Degree in Marine or Mechanical Engineering, together with a sound practical experience. This is an extremely important position and a good salary will be paid to a man meeting the stated requirements. Employment will be at Harwell initially. Box No. W 1262.

SENIOR TELECOMMUNICATIONS Engineer A well known and expanding electronic engineering Company in the London area requires a Senior Telecommunications Engineer to take control of a department dealing with Microwave Link Systems. Applicants should have had considerable previous experience, both in design and application, in this field; preferably holding at present a position as deputy head of a large telecommunications department. A very substantial salary is offered, and a Pension Scheme is in operation. Applicants should be of British Nationality. Please reply stating age, experience, etc., to Box E.E 872 c/o, 191 Gresham House, E.C.2. W 214

SENIOR TELEVISION DEVELOPMENT ENGINEER with administrative experience required. Capable of carrying out development projects with minimum supervision up to production stage. Kingston area. Write giving full personal details stating salary required Chief Engineer, Box No. W 1265.

SHORT BROTHERS & HARLAND LIMITED wish to engage Senior Engineers, Engineers and Technical Assistants for the Electronics Section of their Research Department, to work on Guided Missiles, Computing Systems, Navigational Equipment, and other interesting projects. Applicants should preferably have experience of servo-mechanisms, precision electronic or radio circuits, instruments or test gear. Qualifications required are: Senior Engineers—Honours Degree with at least five years' good engineering experience, and the ability to control a development team. Engineers—University Degree, or equivalent, with several years' experience of development work. Technical Assistants—H.N.C. or equivalent with good practical experience in appropriate field. These are permanent positions in an expanding organization with new and well-equipped laboratories. Good salaries and prospects for men with initiative; pension scheme; assistance with removal and housing. Interviews can be arranged either in London or Belfast. Applications will be treated as strictly confidential. Send full particulars of age, qualifications, experience with salary required to Staff Appointments Officer, Short Brothers & Harland Limited, P.O. Box 241, Belfast, quoting Ref. No. S.A.31. W 2952

SHORT BROTHERS & HARLAND LIMITED have vacancies in their Research Department for two mathematicians to undertake the theoretical investigation of automatic controls, navigational systems, etc. Applicants must possess an Honours Degree, and some experience of electronic, instrument or servo systems. Good salary and prospects in a rapidly expanding organization. Pension Scheme: assistance with housing and removal. Interviews can be arranged in London or Belfast. Applications will be treated as strictly confidential. Send full particulars of age, qualifications, and experience to—Staff Appointments Officer, Short Brothers & Harland Limited, P.O. Box 241, Belfast, quoting Ref. No. S.A.34. W 2953

SHORT BROTHERS & HARLAND LIMITED wish to engage Senior Engineers, Engineers and Technical Assistants for the Electro-Mechanical Section of their Research Department for work on Automatic Controls, Navigational Systems and other interesting military and commercial projects. Applicants should have had some experience of instruments, small Electro-magnetic devices, gyroscopes, or systems employing such components. Qualifications required are: Senior Engineers: Honours Degree plus at least five years good engineering development experience, and the ability to control a development team. Engineers: University Degree, or equivalent, with several years' experience of development work. Technical assistants: H.N.C. or equivalent, with good practical experience in appropriate field. These are permanent positions in an expanding organization with new and well-equipped laboratories. Good salaries and prospects for men with initiative; pension scheme: assistance with removal and housing. Interviews can be arranged either in London or Belfast. Applications will be treated as strictly confidential. Send full particulars of age, qualifications, experience with salary required to Staff Appointments Officer, Short Brothers & Harland Limited, P.O. Box No. 241, Belfast, quoting Ref. S.A.32. W 2954

SIEMENS BROTHERS & CO LTD., have vacancies in their laboratories at Woolwich for Assistant Engineers to carry out experimental work on electronics as applied to long distance telephony. The work covers multi-channel carrier current telephony and telegraphy over long distance open-wire lines and cables in addition to V.H.F. and U.H.F. radio circuits. Field trials for such new equipments afford opportunities for short periods of overseas experience, and young engineers can obtain overseas installation experience. The laboratories are also engaged on the development of specialized carrier current terminal equipment for use with submarine cable systems employing submerged repeaters. Opportunities are available for dealing with mechanical design, the physical principles of component design and the miniaturization of equipment. There are vacancies for young engineers who wish to take up sales and project engineering work involving commercial as well as technical requirements. This work necessitates a period of laboratory training before undertaking overseas travel. Applicants should have Ordinary National Certificate or higher qualification. Experience in the maintenance of multi-channel carrier telephone or telegraph equipment an advantage. Apply Siemens Brothers & Co. Ltd., Ref. 744/11, Woolwich, S.E.18. W 2964

STANDARD TELEPHONES AND CABLES LTD., have vacancies for Engineers, Mathematicians or Physicists, with Degree or Higher National Certificate and experience of Automatic Switching Controls, Computors, or Digital Techniques. Vacancies also exist for Junior Engineers. Apply giving full details of qualifications, experience and salary required to Personnel Manager, Corporation Road, Newport, Mon. W 1313

TECHNICAL ASSISTANT required by manufacturers of telephones and automatic exchanges in S.W. London. Must be able to deal with varied electronic and electrical appliances and write concise English. Good salary and prospects for right man. State education, experience and present salary to Box No. W 1305.

SITUATIONS VACANT (Cont'd.)

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

TECHNICAL AUTHORS. Marconi's Wireless Telegraph Company Limited, Chelmsford, have vacancies suitable for applicants capable of preparing technical descriptions, handbooks, etc., in connexion with Ground and Airborne communication equipments and navigational aids. Permanent and pensionable appointments are offered to selected applicants who must have had some experience of this work. Please apply in confidence to Dept. C.P.S., 336/7 Strand, W.C.2, quoting Ref. 278F. W 2981

TECHNICAL COMMERCIAL ENGINEERS required by progressive company specializing in automatic control switchgear and automatic diesel electric generating plant. Knowledge of telecommunications an advantage. Housing facilities available near modern factory situated 30 miles south of London. Applicants should state age, experience, qualifications and present salary. Box No. W 1285.

TECHNICAL WRITER required by a West London Manufacturer of Domestic Radio and Television Equipment to take charge of a section engaged in the compilation of Service Manuals and similar Publication. Previous experience of this work and a sound knowledge of electronic theory are essential. The position is permanent and pensionable. Apply to Box No. W 2956.

TEST/CALIBRATION engineers for high quality scientific and electronic instruments with good basic knowledge electronics. At least 2 years experience testing/calibrating audio-frequency apparatus. Full details, L.M.K. Manufacturing Co. Limited, Harlequin Avenue, Great West Road, Brentford, Middlesex. W 1283

TESTERS required for high-grade Radar and Electronic work. Ordinary or Higher National Certificate an advantage, but men with suitable Service or Civilian experience will be considered. Opportunities of advancement available for progressive candidates. Good rates of pay, canteen facilities, etc., etc. Apply to the Employment Department, Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester 17. W 2786

TEST GEAR DESIGN ENGINEERS and Maintenance Engineers required with practical experience of this class of work, based on sound knowledge of electronic principles. These vacancies are permanent and progressive. A Company Pension Scheme in operation. London area. Please write, in confidence, giving full details of qualifications to Box No. W 2944.

TEST GEAR DESIGN ENGINEERS and Maintenance engineers required with practical experience of this class of work, based on sound knowledge of electronic principles. These vacancies are permanent and progressive. A company pension scheme in operation. London area. Please write in confidence, giving full details of qualifications to Box No. W 2920.

TELECOMMUNICATIONS (RADIO TRANSMISSION) Engineer required by large organization in the North West to train for position in Technical Publicity Department. Applicants should be aged between 25-30 years, and should have a good general educational background with the ability to write clear concise English. A sound knowledge of modern telecommunications techniques, including V.H.F. and U.H.F. multi-channel systems and Frequency-shift signalling practices, essential. The position is on the established staff of the Company, with contributory Pension Fund, and usual staff conditions and amenities. Please write to Box No. 434, Dorland Advertising Ltd., 18/20 Regent Street, London, S.W.1, giving details of age, qualifications and experience. W 2877

TELECOMMUNICATIONS (LINE TRANSMISSION) Engineer required by large organization in the North West to train for position in Technical Publicity Department. Applicants should be aged between 25-30 years, and should have a good educational background with the ability to write clear concise English. A sound knowlege of modern telecommunications techniques, including coaxial and other multi-channel carrier telephone and telegraph systems, essential. The position is on the established staff of the Company, with contributory Pension Fund, and usual staff conditions and amenities. Please write to Box No. 438, Dorland Advertising Ltd., 18/20 Regent Street, London, S.W.1, giving details of age, qualifications and experience. W 2878

TELEPHONE ENGINEERS. A well-known London company manufacturing Telecommunications equipment have vacancies in their Sales Section for (a) Engineers for preparing tenders, (b) Engineers for editing and writing technical publications, (c) Engineers for instructing and training customers' engineers. Should have good knowledge of carrier telephone and V.F. telegraph systems. Canteen and Sports Club facilities. Pensionable Staff posts. State age, qualifications and experience. Box No. W 2965.

THE BRITISH THOMSON-HOUSTON CO. LTD., require a number of engineers to be trained as technical representatives for duty with the R.A.F. These engineers will be required to advise on the maintenance of airborne electronic equipment. Applicants should have Higher National Certificate or equivalent together with practical experience on electronic equipment. Apply: Construction Department, British Thomson-Houston Co. Ltd., Rugby. W 3012

THE EXPANDING Radar and Radio Division of Elliott Brothers (London) Ltd. has vacancies for: (a) Two Senior Electronic Engineers to carry out development work on interesting new radar and display projects. Candidates, who should be conversant with the principles and design of auto-follow and display circuitry, and with the design of I.F. amplifiers for pulse signals, should have had responsible study design experience and be in a position to lead a small group. (b) Junior Electronic Engineers to assist on the development of radar and display projects. Candidates should have had experience in one or more aspects of radar circuit techniques and be capable of carrying out experimental work with a minimum of supervision. (c) Senior Mechanical Designer to undertake the design of complete radar systems. Candidates must have had a first-class Mechanical Engineering training and at least five years' experience on microwave scanners and their associated mountings and waveguide components. A sound theoretical approach to such problems as stabilization is essential, together with the more practical knowledge of electronic component layout, and requirements of high voltage equipments. Candidates will be required to direct a team of Draughtsmen and to take full responsibility for the mechanical aspect of a project. This post is an important one and holds considerable interest and advancement. Applicants should write giving details of qualifications and experience to: Personnel Officer, Elliott Brothers (London) Limited, Airport Works, Rochester, Kent. W 3026

THE EDISON SWAN ELECTRIC COMPANY LTD., have vacancies in their Special Products Development Laboratory for Engineers for Development work on a wide range of electronic instruments and apparatus for Medical, Industrial and Government use. Please write, stating experience, age and salary required to 155 Charing Cross Road, London, W.C.2, reference SP/LAB. W 213

THE GENERAL ELECTRIC COMPANY, Stanmore Laboratories, Guided Weapons Trials Group have a number of vacancies for technical staff to be filled during the next few months. They call for a good general understanding of the theory and functioning of radar or similar equipment, and academic qualifications preferably of Degree or equivalent standard. The work will involve association with aircraft operations and opportunities for flying may be available. Apply in writing to The Staff Manager, The Grove, Stanmore Common, Middlesex, or telephone to Bushey Heath 2441, Ext. 22. W 2925

THE GENERAL ELECTRIC CO. LTD., Brown's Lane, Allesley, Coventry, requires Mechanical Development Engineers, Designer-Draughtsmen and Draughtsmen, preferably with experience of Radar type equipments for work on Guided Weapons and like projects. Also required, Senior and Junior Electronic Development Engineers, particularly in the field of Microwave and Pulse Applications. Salary according to age, qualifications and experience. Apply by letter stating age and experience to the Personnel Manager. Ref. R.G. W 208

THE PLESSEY COMPANY LIMITED of Ilford offers attractive permanent positions to draughtsmen, due to expansion of our electronic division. Applicants should be experienced in development and design for production of high grade communications equipment to service requirements. Good salary and staff conditions. Company superannuation and insurance scheme in operation. Applications, which will be treated in confidence, should be addressed to The Plessey Company Limited, Vicarage Lane, Ilford, Essex. W 2919

THE TELEGRAPH CONDENSER CO. LTD., require Radio and TV Engineer with laboratory experience for work in connexion with printed circuits. H.N.C. standard. Superannuation scheme. Write giving full details of education and experience, age and salary required to Personnel Manager, T.C.C. Ltd., North Acton, W.3. W 2933

THE TELEGRAPH CONDENSER CO. LTD., invite applications from Engineers fully experienced in Radio and Television design to assist Chief Development Engineer in development of printed circuits. Qualifications at least to A.M.I.E.E. standard. This position offers scope for the right man who must be capable of initiating and following projects to finality, including contact with customers. Superannuation scheme. Write giving full details of qualifications and experience, age and salary required, to Personnel Manager, T.C.C. Ltd., North Acton, W.3. W 2932

TRANSFORMER and Filter design Engineer required to take charge of design and manufacture. Qualifications and experience essential. Apply, to Personnel Manager, Pye Telecommunications Ltd., Ditton Works, Cambridge. W 2930

TRANSFORMER DESIGNER required for development projects involving audio-frequency power transformers, pulse transformers, oil-filled units, etc. Apply stating age, qualifications and experience to the Personnel Manager (Ref. R.G.), The General Electric Co., Ltd., Brown's Lane, Allesley, Coventry. W 192

TWO GRADUATE PHYSICISTS or electrical engineers with an interest in electronic engineering are required for the development of equipment for the measurement of the properties of semiconductor materials and devices. Previous experience in the design and construction of electronic equipment is desirable for one of the vacancies. Box No. W 2922.

VENEZUELA: A company in Venezuela representing well known British manufacturers of radar and electronic equipment has requested its principals to recruit a man of experience with the object of forming an electronic section of the company in Venezuela. The man required must have the necessary technical qualifications and experience in radar and electronic equipment both for marine and air use and in defence applications. Technical sales experience is an advantage. A single man able to speak Spanish is preferred. The salary for the initial contract period of one year, will be in the region of 3,500 to 4,000 Bolivares per month (equivalent of approximately £400 per month). Please write full details qualifications, experience and all relevant information to REF: RS Box No. W 2913.

SITUATIONS VACANT (Cont'd.)

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

ULTRA ELECTRIC LTD., Western Avenue, Acton, W.3 announce the following vacancies for Engineering Staffs. (1) Television Development. (a) Senior Engineers required for T.V. Receiver design. Applicants should have good academic qualifications and experience of the design of radio frequency amplifiers, preferably up to frequencies of the order of 200 Mc/s. (b) Senior Engineers for Time Base development. Applicants should have good academic qualifications and previous experience in the design of T.V. Scanning circuits. (c) Junior Engineers with academic qualifications or experience in T.V. Receiver development. (2) Radio Development. (a) Senior Engineers required for development of radio receivers, embodying the most recent AM/FM techniques. Knowledge of F.M. receiver design desirable. (b) Junior Engineers required for receiver design; experience desirable but not essential if possessing Higher N.C. or C. and G. (Telecoms.) Final Cert. (3) Electronics (a) Senior Electronics Engineer with some experience of circuit design for work in one of the following: (i) Pulse techniques and general waveform circuitry. (ii) Radar Display. (iii) Feedback techniques at video frequencies. (iv) Simple Servo devices. Successful applicants will have opportunities of studying recent American techniques and they should be capable of accurate recording of experimental and design data and the preparation of technical servicing information. (b) Electronic Engineers for work on one or more of the above subjects. (4) Test Equipment Development. (a) Test Equipment Development Engineer for design and development of production test equipment for T.V., radio or contract work. Applicants should have Higher N.C. or equivalent and good experience. (b) Junior T.E. Engineer with some qualifications or preferably some experience. (c) Measurements Section Laboratory Assistant (m. or f.) with some technical knowledge and experience of calibration and certification of electronic equipment. Applicants are requested to write to the Personnel Manager, stating which of the post(s) desired and giving full details (in strictest confidence) including age, experience and salary expected. Saturday morning interviews can be arranged if desired. W 3031

Further "Situations Vacant" advertisements appear in display form on pages 103, 108, 128, 133 and 139.

SITUATIONS WANTED

SENIOR ENGINEER. 33. D.F.H. five years' experience in the G.W. field including a trial department, seeks post calling for organizational ability. London area. Box No. W 1303.

TELEVISION BROADCAST ENGINEER. A.M.I.E.E. Extensive experience, desires superior commercial post. Box No. W 1311.

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COMPARABLE in specification with amplifiers costing double its price of £25 the "Rogers Rd Junior" is in stock and strongly recommended by Webb's Radio, 14 Soho Street, London, W.1. W 196

LARGE QUANTITY of Toggle Action "Quick Make and Break" Units suitable for 30/60 amp. Switchgear for disposal. Cancelled export order. Samples on request. Box No. W 1302.

MAGSLIPS. SELSYNS and many other items connected with automatic and remote control mechanisms are marketed by Servo & Electronic Sales Ltd. Brochure available on request. See our display advertisement on page 142. W 202

METAL-GLASS SEALS. Single way hermetically sealed terminals for soldered connexions and fixing. Mostly 1kv and 2kv sizes. New: 65s. per 1,000 assorted. P. B. Crawshay, 94 Pixmore Way, Letchworth, Herts. Tel. 1851. W 215

POWER EQUIPMENT BARGAINS. Potted Mains Transformers. These are of really superior construction fitted in cast metal cases and compound filled. Terminals come to ebonite baseboard. All are upright mounting and have 220/230 normal 50 cycle mains input and fully screened primary. Type 5F1. 265-0-265 at 300 m.a.; 6.3 v. at 7 amp.; 4.4 v. at 2.5 amp.; Price 35s. plus 3s. 6d. carriage. Type 5F2. 365-0-365 at 150 m.a.; 4 v. at 2.5 a.; 6.9 v. at 4.2 a.; Price 32s. 6d., carriage and packing 3s. 6d. Type 5F3. 1540 v. 2 v. at 2 a.; 4 v. at 1 a. This is an ideal transformer for televisors and scopes using V.C.R.97, etc. Price 25s. carriage 2s. 6d. Potted Chokes. These chokes are in similar type cases and therefore match the above transformers. Type 5F4. 5 H. at 300 m.a. Price 10s. carriage and packing 2s. 6d. Type 5F5. 10 H. at 150 m.a. Price 12s. 6d. post and packing 2s. 6d. High Power Transformers. For R.F. Heaters, transmitters, etc., etc. These are open wound type for maximum cooling and have the normal 200-250 primary fully screened. Type 5F6. 1,000 v. at ½ amp. e.g., 5 K.V.A. Price £8 10s., carriage and packing 5s. Type 5F7. 1,500 v. at 1 amp. e.g., 1.5 K.V.A. Price £15, carriage and packing 7s. 6d. Type 5M1. 1,000-0-1,000 v. at 1.5 amps. e.g., 1½ K.V.A. Price £12 10s., carriage and packing 7s. 6d. Type 5M2. 1,000-0-1,000 v. at 500 m.a. and 4 v. at 4 a. Price £7 10s., carriage and packing 4s. 6d. Type 5M3. 375-0-375 v. at 250 m.a. and 4 v. at 4 a. Price 37s. 6d., carriage and packing 3s. 6d. Power Filament Transformers. Type 5M4. 4 v. at 4 a. 2-0-2 v. at 10 a. Price 18s. 6d., carriage and packing 3s. 6d. Type 5M5. 3.15-0-3.15 at 10 a. 4-0-4 at 10 a. 4-0-4 at 2 a. 4 at 4 a. 2.5-0-2.5 at 3 a. Price 27s. 6d. plus carriage and packing 3s. 6d. Type 5M6. 34 v. at 2 a. tapped 32 v., 30 v. and 28 v. for relays, etc., 22s. 6d. plus 3s. 6d. carriage and packing. Power Chokes. Open wound type and feet with clamps. Type 5M7. 30 Henry at 500 m a., 35s. Type 5M8. 20 Henry at 500 m.a. 32s. 6d. Type 5M9. 15 Henry at 500 m.a. 27s. 6d. Type 5M10. 10 Henry at 500 m.a. 22s. 6d. Type 5M11. 25 Henry at 250 m.a. 18s. 6d. Type 5M12. 3 Henry at 10 amps. 18s. 6d. Type 5M13. 200 Henry at 5 m.a. 15s. E.P.E. Ltd., Special Sales Dept., 31 Bourne House, Grove Road, Eastbourne. W 185

STAINLESS STEEL BALLS. Phosphor Bronze and Brass Balls, Miniature Balls and Bearings: prompt delivery. Insley (London) Ltd., 21/22 Poland Street, London, W.1. Tel. GERrard 8104 and 2730. W 1177

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METALWORK. All types cabinets, chassis racks, etc., to your own specifications. Philpott's Metal Works Ltd. (G4BI), Chapman Street, Loughborough. W 2776

THE POLYTECHNIC, Regent Street, W.1. Electrical Engineering Department, Head of Department: D. O. Bishop, Ph.D., M.I.E.E. A special course of six weekly lectures dealing with High-Fidelity Sound Reproduction has been arranged for Thursdays at 7 p.m. commencing 19th May 1955. The lectures will cover various aspects of sound recording and reproduction and will be given by leading specialists from industry. Particular attention will be devoted to the latest developments. The fee for the course is £1. Further details may be obtained on application to the undersigned. J. C. Jones, Director of Education. W 2983

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WANTED

WANTED. Electronic Engineering November 1948 required. Reply Technical Library, E. K. Cole Ltd., Ekco Works, Malmesbury. W 3046

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WAVE WINDING capacity available. Avis & Baggs Ltd., Gosbrook Road, Caversham, Reading. W 2990

WEBB'S SERVICE DEPT. for complete renovation of complex communication receivers of any make. Test report issued showing sensitivity selectivity, signal/noise equal to, or better than, maker's original figures. Webb's Radio, 14 Soho Street, London, W.1. W 196

AGENCIES

ELECTRONIC DISTRIBUTING AGENCY situated in S.W. England, contacting industrial and Government departments wishes to handle further lines of high-grade test or electronic instruments r.f. heating, telecommunication, general research or specialized equipment. Box No. W 1293.

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PRECISION ENGINEERING AND MOULDING. London firm of designers and manufacturers of components for electronic equipment with first-class facilities and organization for research, design and development as well as sales and contracts and commercial administration, would like to meet similar small firm with strong over-all technical direction and production management, who could benefit from additional orders and the organization described above, in order to discuss collaboration or amalgamation. Please write in the first instance to Box No. W 3016.

PATENTS

BRITISH PATENT NO: 656,486. Installation for wireless calling in circuits comprising combined transmitting and receiving stations. British Patent No: 660,579. Improvements in or relating to devices for phase modulation of electric oscillations. British Patents No.: 660,645. Improvements in or relating to devices for phase modulation of electric oscillations. The proprietors of the above Patents are desirous of entering into an arrangement by way of a Licence or otherwise on reasonable terms for the purpose of exploiting the above Patents and ensuring their practical working in Great Britain. All inquiries to be addressed to Heron Rogers & Company, Bridge House, 181 Queen Victoria Street, London, E.C.4. W 2906

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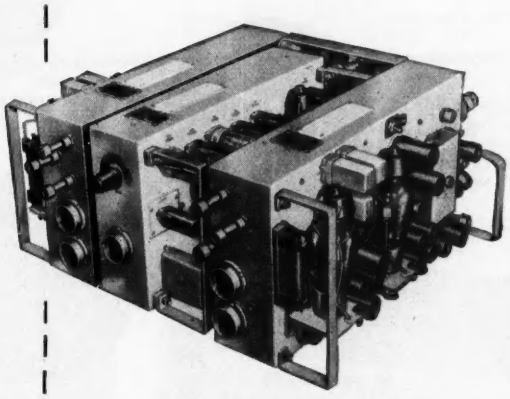
At the Electronics Division of Plessey, a thousand pairs of trained hands can, if need be, nurse a young idea—develop it—and bring it to full or limited production maturity with a thoroughness that would spell costly delay in any organisation less well equipped. The Division is presently engaged on contracts for for such renowned organisations as B.T.H., Decca, I.A.L., Kelvin Hughes, Marconi's Wireless Telegraph Company Ltd., and Laurence Scott & Electromotors Ltd. If your special interests lie in electronics, serve them well by writing for the Plessey publication which sets out the Division's specialised services.



Part of a particularly compact radar installation made for Marconi's Wireless Telegraph Company Ltd.

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PE 2a

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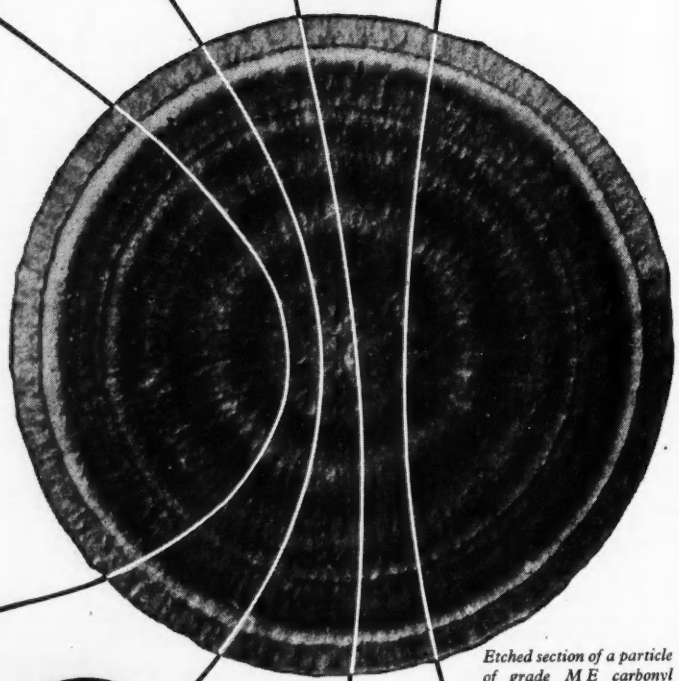

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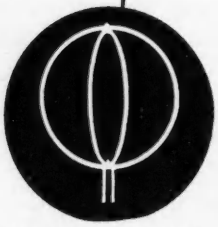
Toroidal and shrouded cores for carrier telephony.



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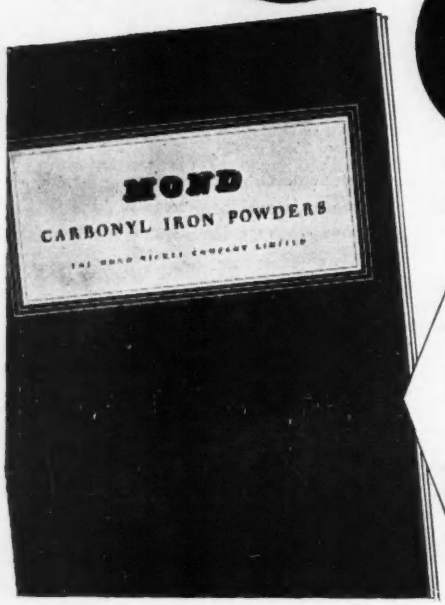

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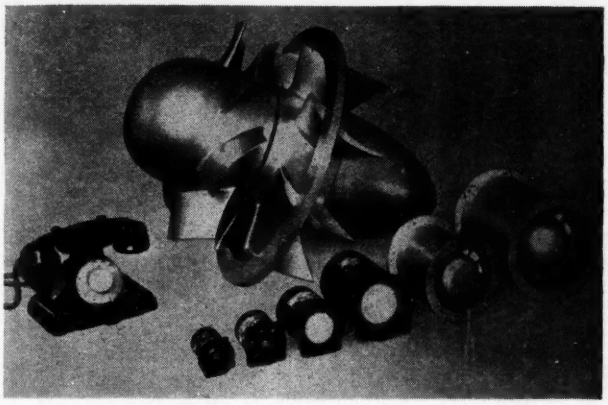

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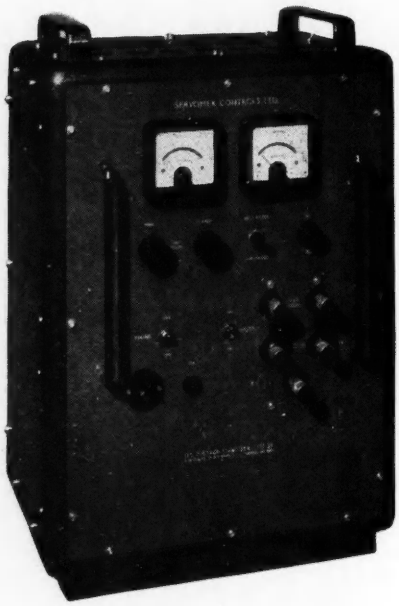
D.C. VOLTAGE STABILISERS

Low Voltage, High Current

D.C.3. 7 amp.

Output 1-30 volts, at 0-7 amps. The steady-state stability is ± 25 mV for load and mains changes. Rectifier ripple less than 0.05% peak. Time of response is about 200 mSec., for small errors.

D.C.38. 2·5 amp.



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These Stabilisers both employ a continuous servo with velocity feedback. They are insensitive to change of frequency—load power factor—temperature—supply waveform. They are unaffected by vibration and bumping, and have excellent long-term stability. Other important features are :—

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3. **Metered for current and voltage.**
4. **Large power.**
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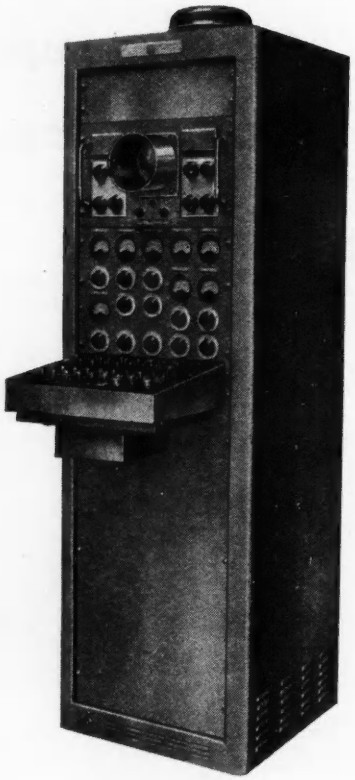

This equipment displays on a cathode-ray tube a family of Ia/Vg curves for any receiving type thermionic valve. Eleven curves corresponding to eleven different grid voltages are presented simultaneously and a calibrated graticule permits rapid comparison with published data.

Nine standard valve bases are provided, with facilities for connecting others, and the various valve electrodes are connected to the requisite supplies by a multi-button switching board.

This permits any electrode to be connected to any supply without damage and also enables electrodes to be paralleled for test purposes.

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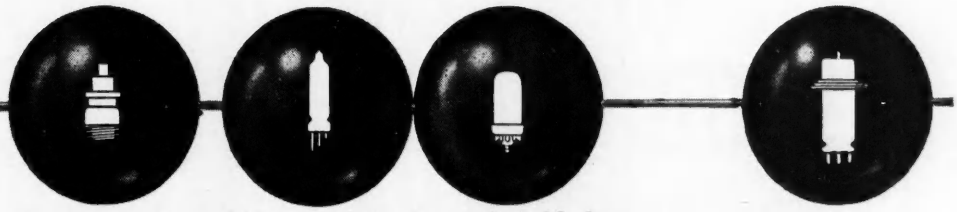
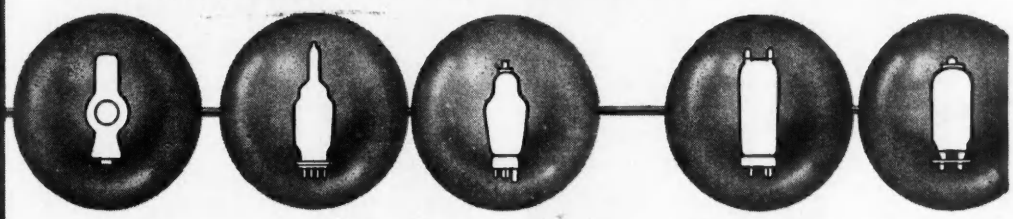


Communication and Industrial Valves



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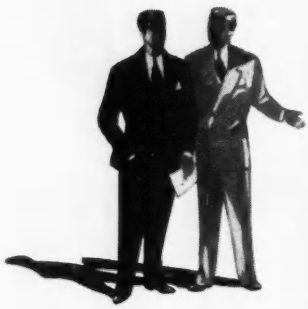

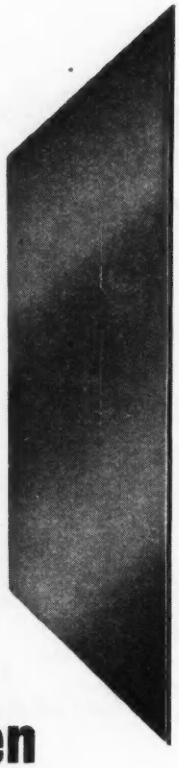

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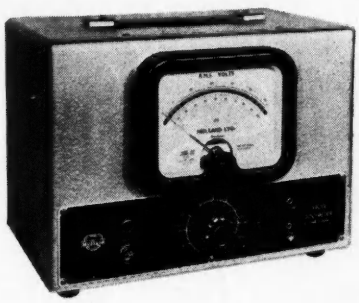
VALVE VOLTMETERS
by Mullard

E.7556



E.7556

SENSITIVE

F.S.D. readings range from 10mV to 300V r.m.s. a.c.

LEVEL FREQUENCY RESPONSE

Only 2% (0.2dB) variation between 20 c/s and 1 Mc/s.

ACCURATE

Absolute error is less than 4% over whole range.

NEGATIVE FEEDBACK

The calibration accuracy is precisely maintained in this valve voltmeter, and in the E.7555 series described below.

BUILT-IN CHECK VOLTAGE

A stable 10mV supply provides a quick and easy check of calibration.

E.7555/2

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0.5V F.S.D. to 15kV, peak a.c. or d.c. (an alternative model, **E.7555/3,** with a range of 0.5V to 500V is also available.)

BROAD BANDWIDTH

Low level response constant within 2% from 30 c/s to 100 Mc/s using probe.

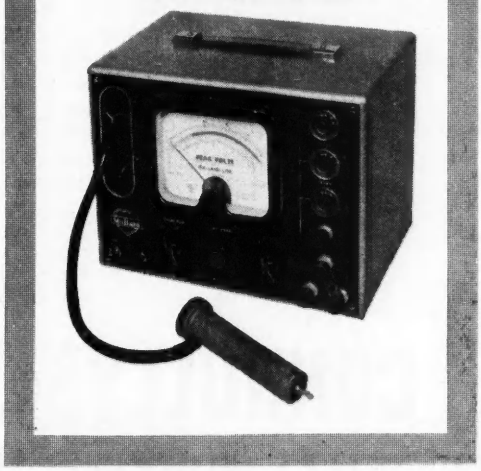
EXTREME STABILITY

The high degree of feedback employed minimizes the effects of ageing and supply fluctuations.

DIFFERENTIAL MEASUREMENT

Provision is made for differential measurement of direct voltages and, at the same time, for the input resistance to be balanced to earth.

E.7555/2



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- **Built in 500 kc's crystal oscillator facilitates calibration checking.**
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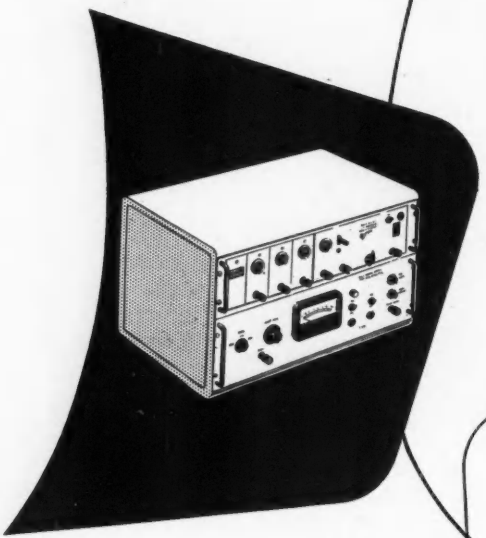
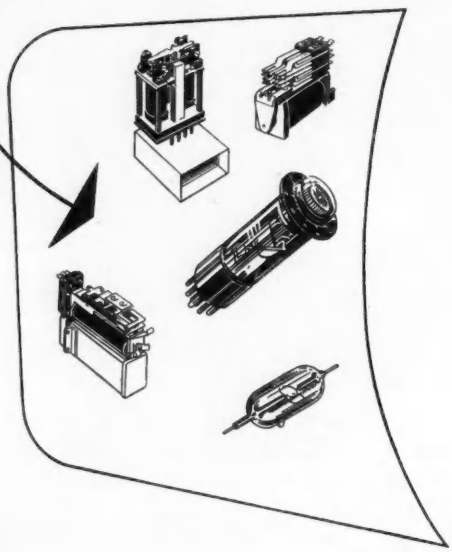


For 50 years we have enjoyed a high reputation for our standard of performance, reliability and finish in the communication field. We have now, in addition, brought this skill, experience and craftsmanship to the development and manufacture of a wide range of electronic and nucleonic instruments.



As originators of the Dekatron and other reliable cold cathode tubes and a variety of new electromechanical devices we feel that we are making a positive contribution to the Instrument field.

Consult us for all counting, scaling, timing and similar problems and components.

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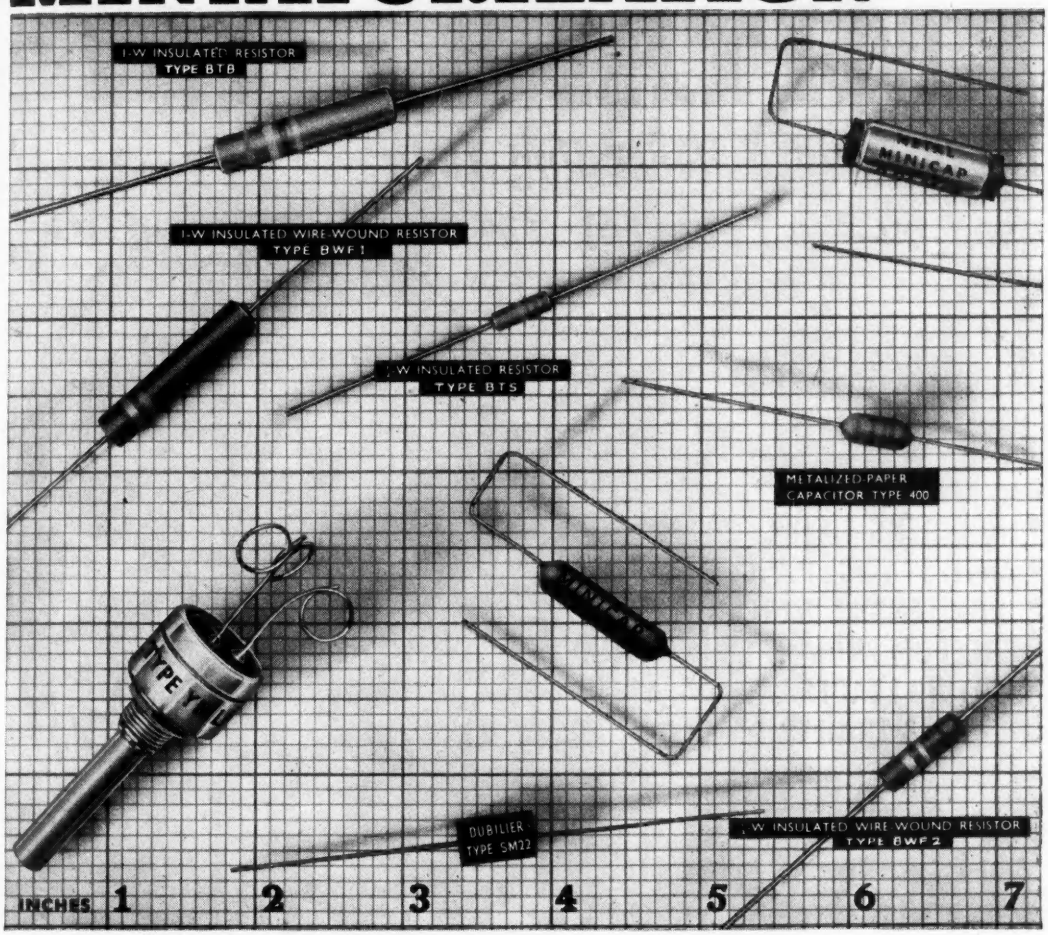

Tiny valves and transistors demand tiny components to accompany them. Whether you are working on television for Bands III and IV, Band II Radio, computors, industrial electronics or test gear, these components will undoubtedly interest you. Deserving of special mention are the tiny BTS type ¼-W. resistor measuring only ⅜″ × ⅛″ and the type 400 metallised paper capacitor in its melt-proof cover. For those of you concerned with tropicalization, BTS, BTB and BWF2 resistors, YN-potentiometers and metal 'minicap' capacitors will be of special interest. To those of you engaged on Government contracts we should like to mention that the metal 'minicap' capacitor and the type BTS and BTB resistors are type-approved. Send for samples and catalogues by dropping us a line on your company's letter-heading.

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You will see these latest developments on Stand No. 45.

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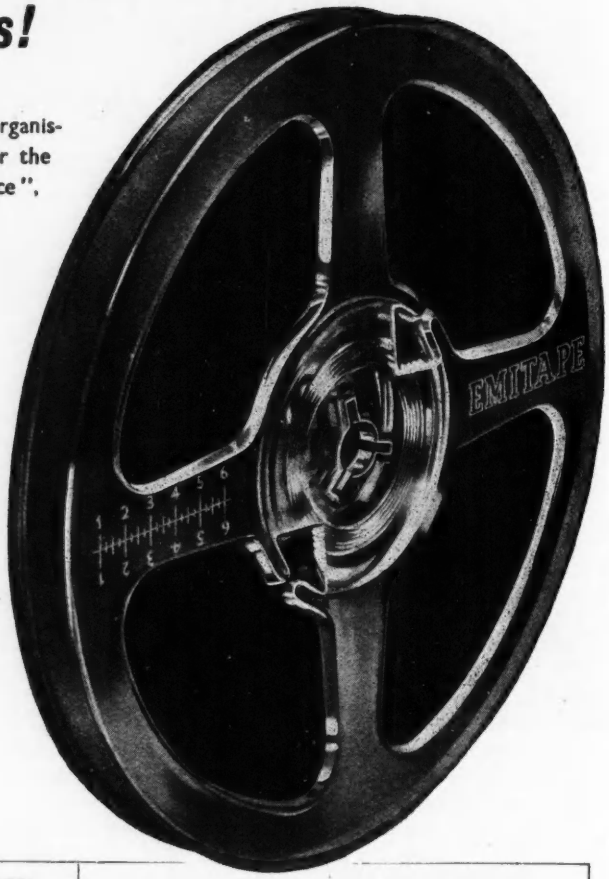

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(Metallic contact strip on 5" spool for auto-stop)

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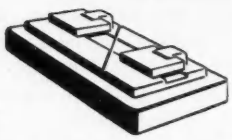

Magnetic Tape Jointing Block AP46 Price 8s.

Non-Magnetic Scissors AP39 Price 16s.

Manufactured and distributed by:

E.M.I. SALES & SERVICE LTD.

RECORDING EQUIPMENT DIVISION, HAYES, MIDDLESEX.

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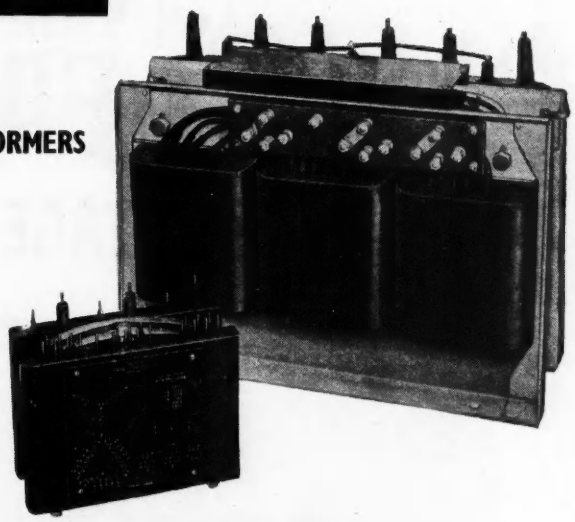

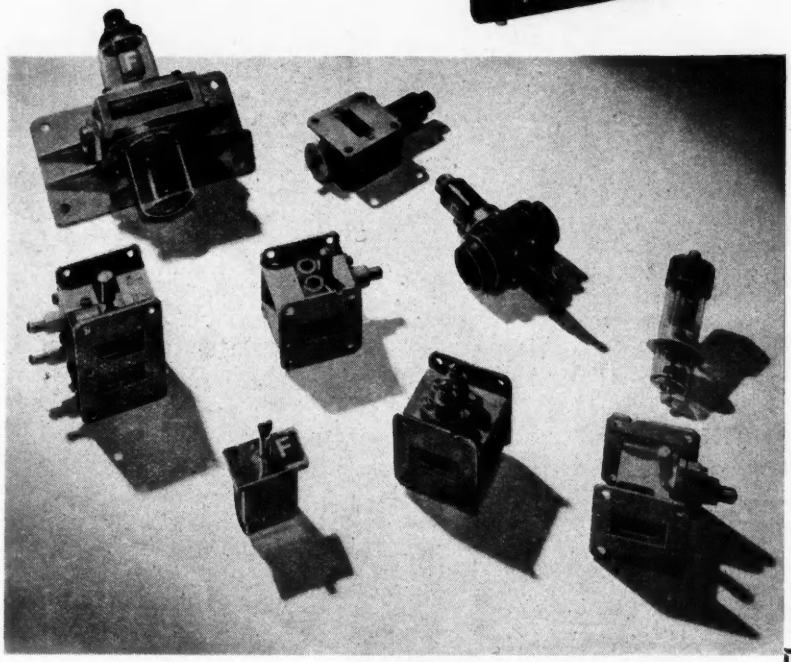

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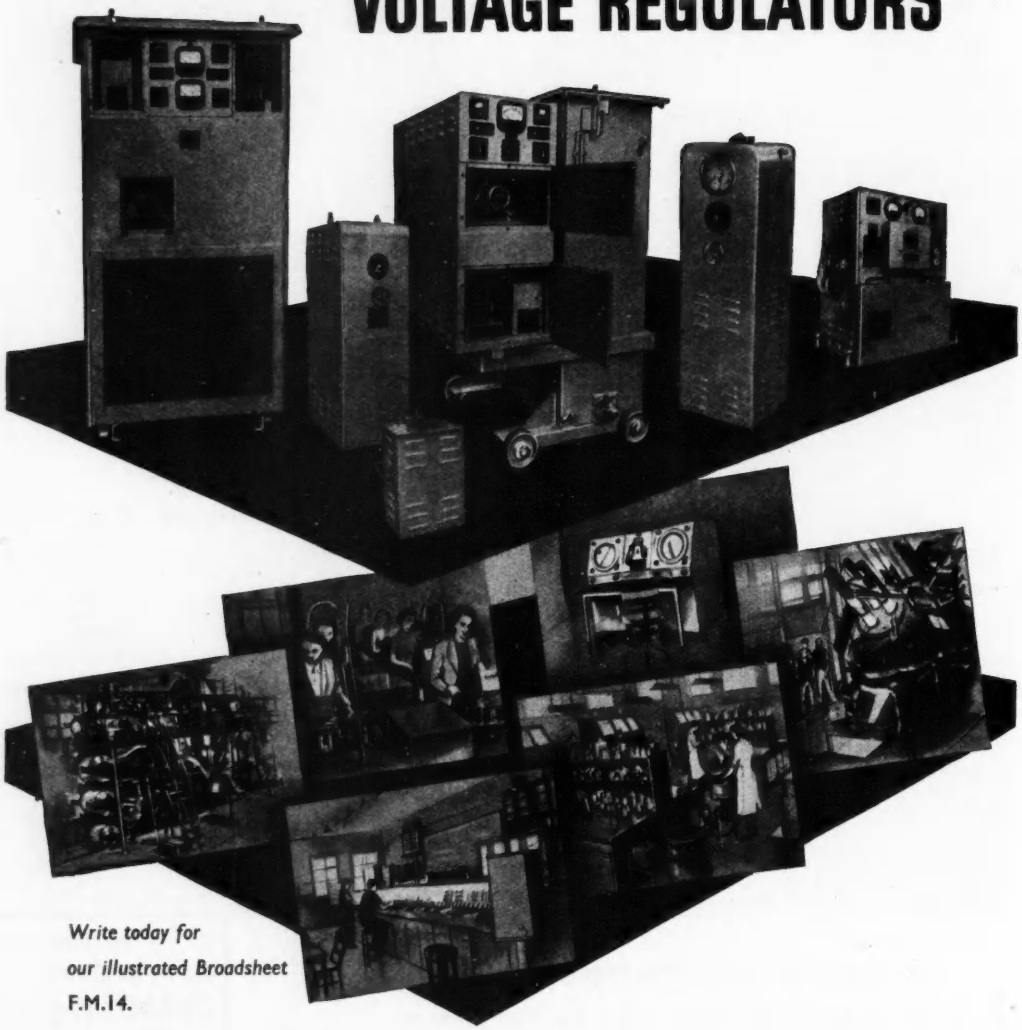

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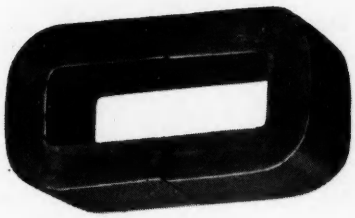
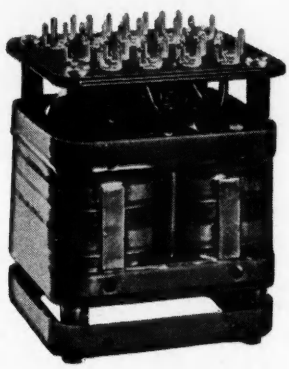
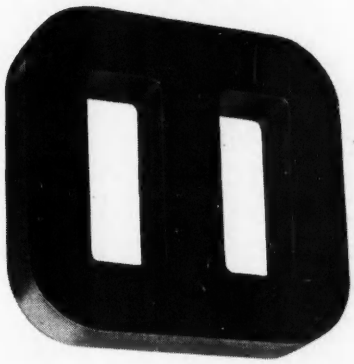
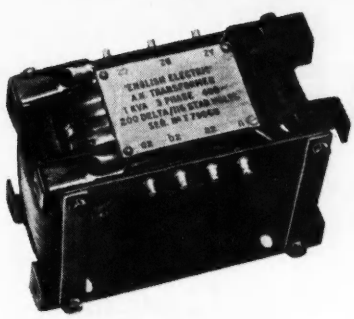
'C' Cores and 'E' Cores
for transformers and chokes









'ENGLISH ELECTRIC' 'C' Cores and their later development, 'E' Cores, are ideal for use in open type transformers and chokes as well as the oil-filled or cast resin types. Their use enables the complete transformer to be up to 30% smaller and lighter. Made in a comprehensive range of sizes, most 'C' Cores are available from stock and normal requirements of 'E' Cores on a short delivery.

Full details of 'C' and 'E' Cores are given in the latest edition of the 'ENGLISH ELECTRIC' Designers handbook TF.229. Write to Transformer Sales and Contracts Department, East Lancashire Road, Liverpool 10.

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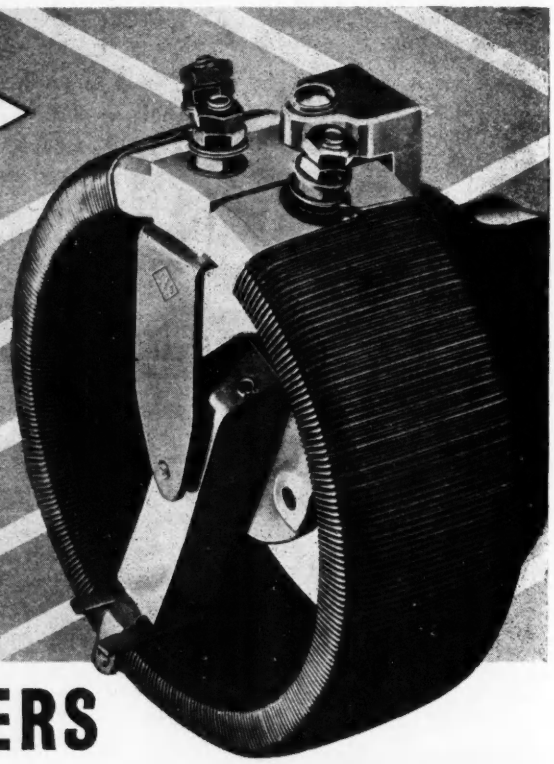

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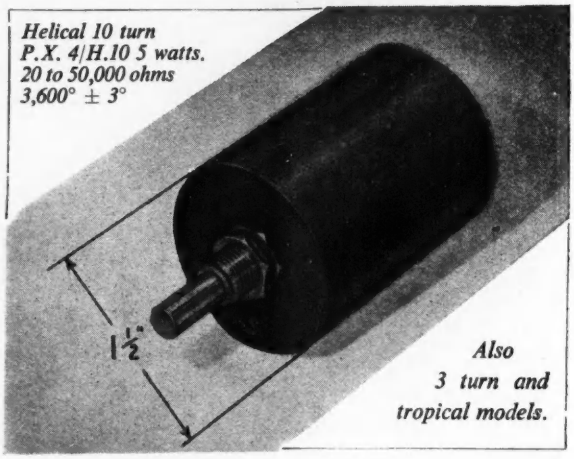

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P.X. 4/H.10 5 watts.
20 to 50,000 ohms
3,600° ± 3°

Also 3 turn and tropical models.

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Tel: Horsforth 2831/2 Grams: Toroidal Leeds

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STABILISED POWER SUPPLY UNIT FOR PHOTO-MULTIPLIERS

Ediswan now have available a new stabilised power supply unit which has been specially designed to feed Photo-Multipliers. It is particularly suitable as a supply unit for Ediswan Mazda Photo-Multipliers type 27.M1, 27.M2 and 27.M3.

BRIEF SPECIFICATION—Type R.1184

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200–250 v., 40–100 c.p.s.	High stability low ripple D.C. supply variable between 300 and 1,100 volts. Max. current 2 mA. Pos. or neg. may be earthed.	A 10% change in mains input voltage results in a change of less than 0.1% between 1,100 volts and 600 volts output.	Approximately 1,500 ohms.	Less than 0.01% R.M.S.
MOUNTING The Unit is suitable for standard rack mounting or for bench use. Bench Stands are available.				

PRICE — £48

Further information is available on request

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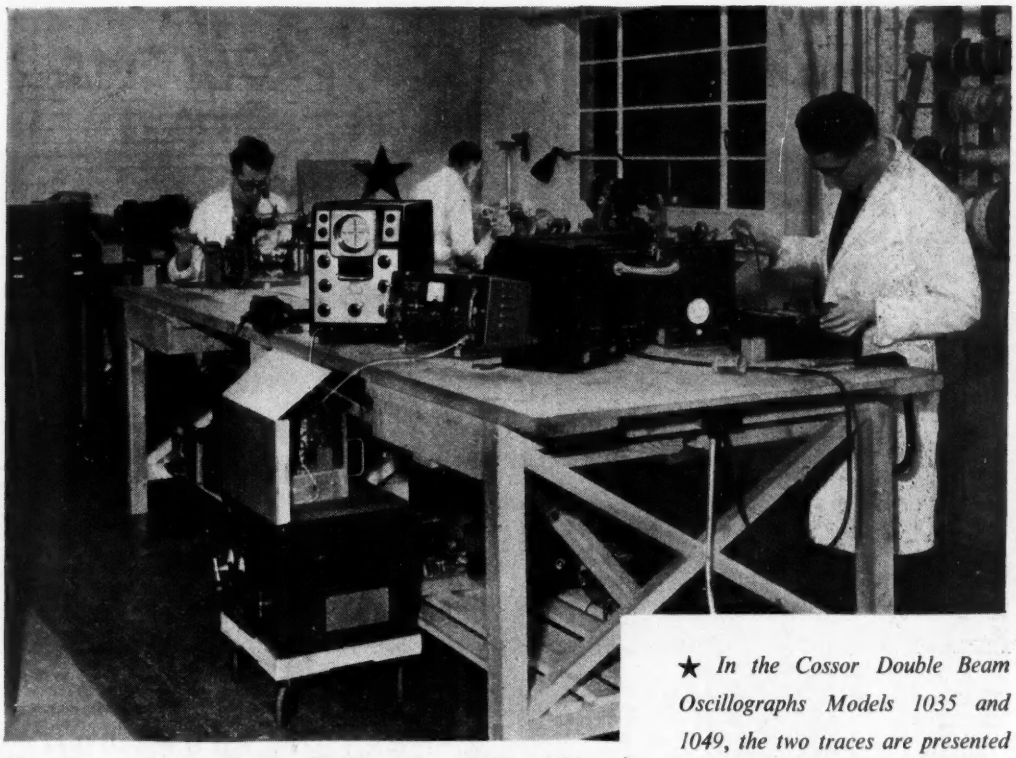


The Cossor Double Beam Oscillograph Model 1035 in use in the Research laboratories of Saunders-Roe Ltd., the famous flying boat manufacturers.

In displaying the mutual effect of two related and variable quantities simultaneously the Cossor Double Beam Oscillograph is solving many of the fundamental problems with which the Research and Development scientist is constantly beset. In the Production field, too, there are innumerable problems capable of complete solution by this versatile instrument and every branch of industry is realising the enormous potential of this apparatus in the detection and analysis of faults and the accurate monitoring of manufacturing processes.

The technical advisory staff of the Instrument Division is always at your service to help with your particular problem.

★ *In the Cossor Double Beam Oscillographs Models 1035 and 1049, the two traces are presented on a flat screen of 90 mm. dia., and the amplifiers are so calibrated that measurement of the voltage input as well as the time interval between various significant portions of the oscillogram is made possible. Permanent records for subsequent analysis may conveniently be made by attachment of Cossor Camera Model 1428, for which there is also a nine-speed Drive Unit Model 1431.*

The Technical Advisory Staff of the Cossor Instrument Division is always at your service.

COSSOR ELECTRONIC INSTRUMENTS

Please address enquiries to C1.68

COSSOR INSTRUMENTS LIMITED (Dept. 14) HIGHBURY GROVE · LONDON · N.5

Telephone : CANonbury 1234 (33 lines *Telegrams : Cossor Norphone, London* *Cables : Cossor, London*

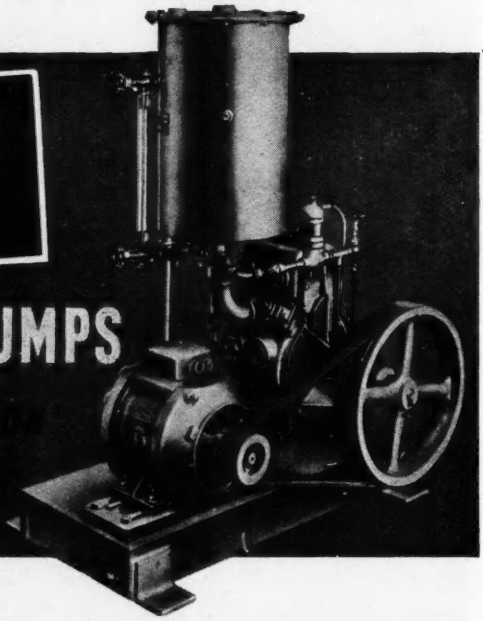
NEW IDEAS SOLVE OLD PROBLEMS

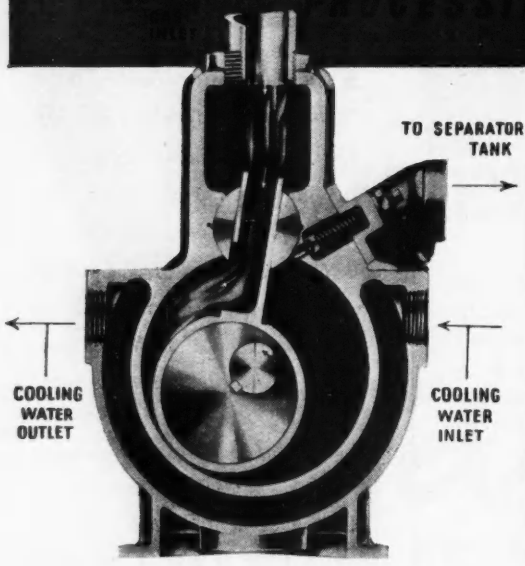
Kinney

HIGH DUTY VACUUM PUMPS

FOR ECONOMICAL PRODUCTION

PROCESSING





OPERATING CYCLE OF KINNEY VACUUM PUMP

The plunger, moving in the direction of the arrow, rapidly creates space into which gas is admitted through the inlet valve. Simultaneously, gas previously trapped is being compressed. When the plunger reaches its highest position, air or gas and surplus sealing oil is expelled through the outlet valve and nozzle into the oil separator tank. There, the oil is retained and the air or gas discharged to the atmosphere. Further movement of the plunger closes the inlet valve and completes the cycle of operation.

KINNEY VACUUM PUMPS SHOW THE WAY

Has it ever occurred to you that Kinney Vacuum Pumps might well solve *your* problems? Cathode ray tubes, electric lamps, coated lenses and mirrors, drugs, foodstuffs, coated foils, condenser papers, electrical components—these are a few of the products now being made quicker, better and more profitably, thanks to Kinney Vacuum Pumps. Models VSD and DVD single stage (10 microns absolute pressure or better); model CVM double stage (0.5 micron or better), displacements 15 to 700 c.f.m. Bulletins 101 and 104 tell you all about them.

GENERAL ENGINEERING CO RADCLIFFE LTD

GENERAL ENGINEERING CO. (RADCLIFFE) LTD.

Station Works, Bury Road, Radcliffe, Lancs.

Telephone: Radcliffe 2291 (3 lines) Telegrams: "General" Radcliffe

London Office: 3rd Floor, 9 Victoria Street, London, S.W.1.
Telephone: Abbey 5278

Portable Wave Analyser

THE WAYNE KERR MODEL A.321

An audio frequency analyser of the heterodyne type to measure the relative levels of the components of a complex waveform down to −75 db below fundamental.
It is light, compact and simple to operate and can be supplied either in a transportable case or for standard 19" rack mounting.

STAND 12 BLOCK C

BRITISH INSTRUMENT INDUSTRIES EXHIBITION
EARLS COURT LONDON
June 28 - July 9 1955

Specification

FREQUENCY COVERAGE:	*50—20,000 c/s in two ranges*
FREQUENCY STABILITY:	*Better than ±1%*
INPUT LEVEL:	*Between −20 and +20 db relative to 1mV into 600 ohms adjusted by a 5 step attenuator and fine control of 0—10 db*
FREQUENCY RESPONSE:	*Flat to within ±1 db over the whole working range.*
LEVEL STABILITY:	*±1 db if mains supply voltage remains within ±5%*
ACCURACY OF HARMONIC MEASUREMENTS:	*Harmonics below fundamental to −55 db ±5% to −75 db ±10% or ±1 db whichever is the greater.*
INPUT IMPEDANCE:	*100,000 ohm unbalanced (greater than 25,000 ohm, balanced, can be supplied to order)*
SELECTIVITY:	*Constant over the frequency range. 2 stage crystal filter, mid band frequency 100 Kc/s. Flat top (±1 db) pass band extending over 10 c/s ±1 c/s.*
HUM LEVEL:	*−55 db*
POWER SUPPLY:	*110/115 and 200/250 volts 40/60 c/s*
POWER CONSUMPTION:	*Approx. 60 watts*
DIMENSIONS:	*In case 20" × 9" × 8½"*
WEIGHT:	*31 lbs. approx.*

PRICE £250 NETT
Immediate Delivery

Wayne Kerr

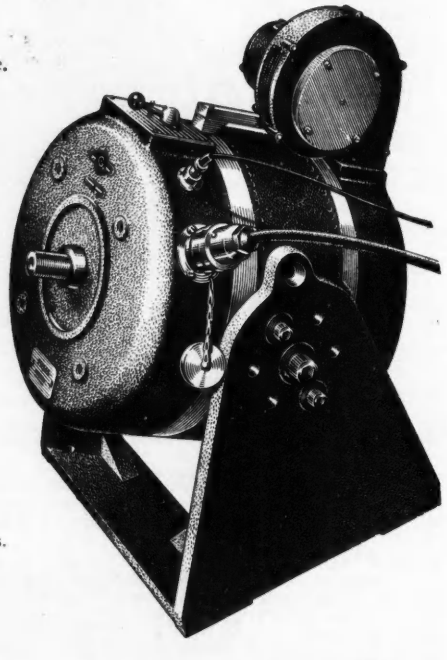
THE WAYNE KERR LABORATORIES LIMITED · NEW MALDEN · SURREY · MALDEN 2202

The part played by **GOODMANS** in *VIBRATION INVESTIGATION*

It is acknowledged that vibration causes metal fatigue. Authoritative opinion is divided as regards the precise investigating approach to fatigue failure—whether the frequency of reversals should be high or low, and the amplitude large or small.

To simulate a particular vibration mode under controlled conditions is to go a long way to discover the critical failure point. And Goodmans Vibration Generators do just that. For certain types of specimen, the standard range of models can be applied to obtain the S.N. Curve. Should this range not offer a solution to your particular problem or method of investigation, a modified arrangement might prove the answer.

Our wide experience in the design and production of electrodynamic generators is at the service of Industry, and we welcome enquiries for specialised applications, with particular emphasis on fatigue testing problems.



GOODMANS **VIBRATION GENERATORS**

The present Goodmans range of Vibrators extends from a model developing ± 300 lb; to a midget with a force output of approximately ± 2 lb.

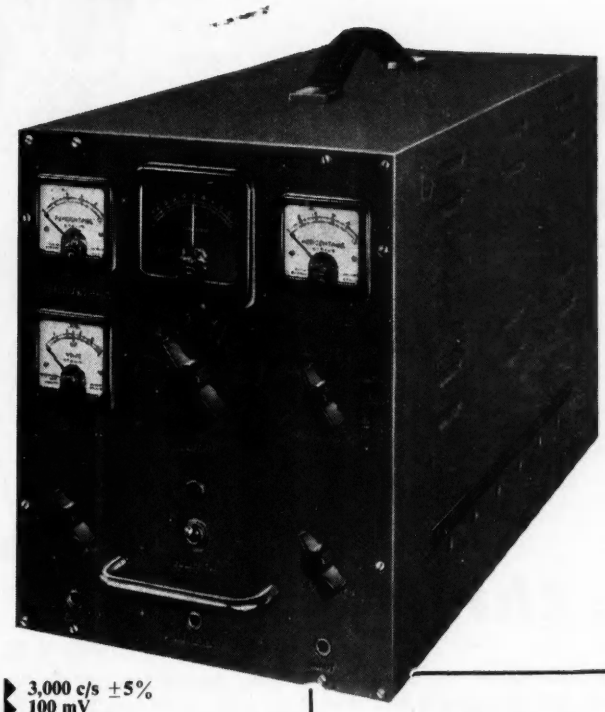
Full details on request to " Vibrator Dept. E."

GOODMANS INDUSTRIES LTD., AXIOM WORKS, WEMBLEY, MIDDX. Telephone: WEMbley 1200 (8 lines)

Made to measure . . .

The Gaumont-Kalee Flutter Meter is an instrument designed to measure small deviations from constant speed occurring in sound recording and/or reproducing machines. Consisting of a narrow band amplifier, a limiter, a discriminator and detector, and a metering system, the whole unit is self-contained with its own power supplies.

The instrument responds down to zero frequency and will therefore indicate accurately the lowest wow components present. The power consumption is 100 watts and the main characteristics of the instrument may be summarised as follows:



Operating carrier frequency	**3,000 c/s ±5%**
Minimum input signal	**100 mV**
Input impedance	**0.5 megohm**
Input amplifier band width	**—2 db at 2,500 and 3,000 c/s**
Effective limiter range	**5:1**
Peak wow meter F.S.D.	**±1% peak (centre zero)**
R.M.S. Meters F.S.D.	**1.0% R.M.S.**
R.M.S. Meters F.S.D. on divide by 5 range	**0.2% R.M.S.**
Cross over frequency	**20 c/s ±10%**
Flutter meter response	**—3db at cross over** **—2db at 200 c/s** **—8db at 300 c/s**
Wow meter response	**—3db at cross over** **—1db at ½ cycle**
C.R.O. Output frequency response	**Level down to zero frequency** **—2db at 200 c/s**
Analyser output frequency response	**—2db at 400 cycles** **—1db at ¼ cycle**
C.R.O. Output Maximum signal	**150 volts Peak to Peak**
Analyser Output for 1% peak to peak deviation	**3.0 volts R.M.S.**
Analyser output must be closed upon 0.5 megohms	
All meter presentations, accuracy ±5% F.S.D.	

FAMOUS USERS
of the
flutter **METER**

B.B.C. Television.
E.M.I. Supplies Ltd.
R.C.A. Photophone Ltd.
Garrard Engineering & Manufacturing Co. Ltd.
Truvox Ltd.
Ministry of Supply.
N.V. Philips' Gloeilampenfabrieken. Holland.
Post Office Research Department.
Compagnia Commerciale di Cinematografia, Milan.
Commision Supérieure Technique, Paris.
N.Z. Broadcasting Service.
Commonwealth of Australia, Melbourne.
Wright & Weaire, Ltd.

GAUMONT-KALEE

flutter **METER TYPE 564**

Conforms to B.S. 1988: 1953

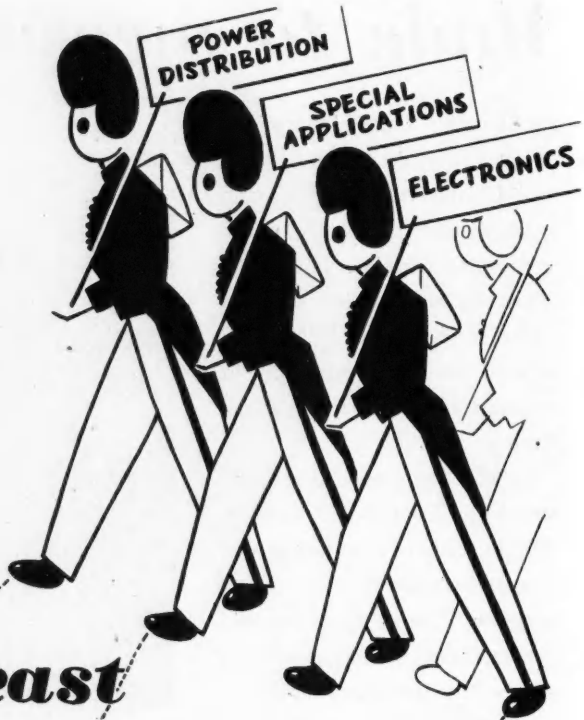
Full details of this equipment may be obtained from

G.B-KALEE LTD. ***The Studio Dept. JSI/2/55***

Mortimer House, 37–41 Mortimer St., London, W.1 **Telephone: MUSeum 5432**

A Member of the **British Optical & Precision Engineers' Group**

We're Marching On...



...three abreast

To keep abreast of the constantly growing demand in new fields for Gresham Transformers the Company's functions have been reorganised into three divisions—Power Distribution, Special Applications and Electronics. Each Division is manned by specialist liaison engineers and designers, and all the technical and manufacturing resources of the Gresham organisation are available to each Division.

POWER DISTRIBUTION DIVISION

The transformers produced by this Division range from 5 to 1500 kVA and are installed in Power Stations, Sub-stations and Rural Areas. The range includes the well-known LOFEL (low iron loss) transformers of 5, 15 and 25 kVA rating.

SPECIAL APPLICATIONS DIVISION

This Division designs and builds transformers for electric furnaces, motor body welding plant, high-frequency heating units, H.F. and V.H.F. transmitter rectifier supply, H.T. laboratory equipment, etc. Mobile sub-stations are supplied to the National Coal Board for mining use.

ELECTRONICS DIVISION

The transformers and chokes used in telecommunications, radar, electronics and instrumentation are designed and made to stringent specifications. The types which have been granted Joint Services Approval are a feature of this Division.

The knowledge and experience of the GRESHAM Specialists are as close to you as your telephone—ring FELtham 2271 (7 lines)

HANWORTH **GRESHAM** TRANSFORMERS LTD MIDDLESEX

BRITAIN'S LARGEST INDEPENDENT TRANSFORMER MAKERS

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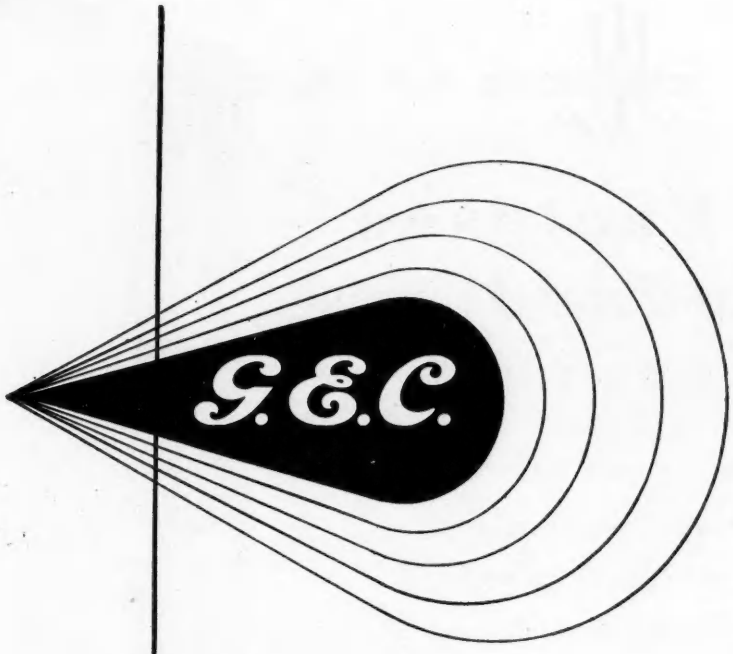


Germanium Diodes

The G.E.C. range of Germanium Diodes comprises high and low back resistance types for use as F.M. and television detectors and noise limiters, V.H.F. mixers, telephony modulators and in other specialised applications.

Germanium Diodes offer many advantages to the designer and they are being increasingly specified for use as clippers, clamping diodes, etc., in modern electronic equipment.

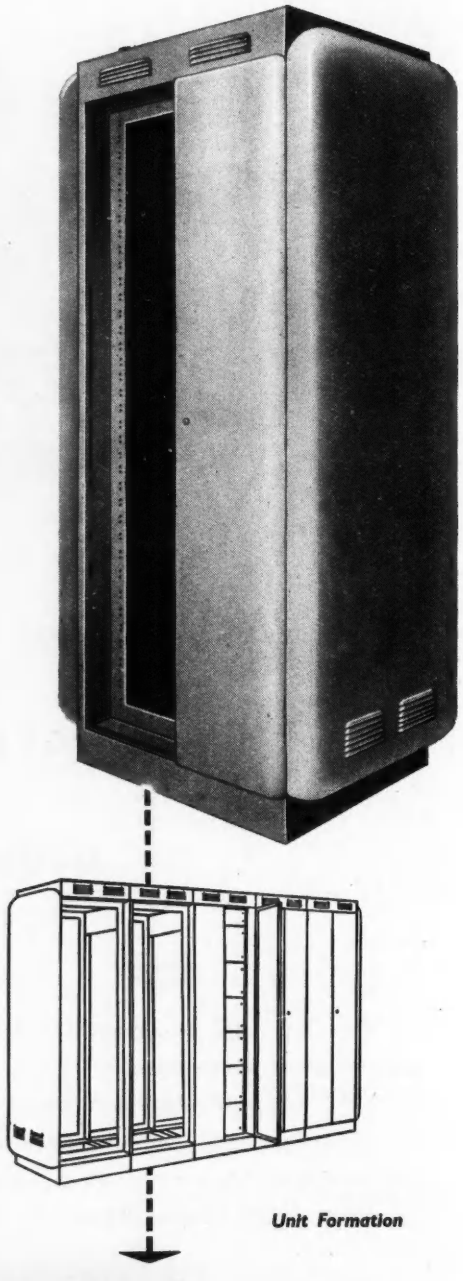
GEX 56 *This high grade crystal which has only recently become generally available is of special interest to the electronics engineer. It is a very high-back resistance diode with a forward current of 1 mA at + 1 V, and a reverse current of less than 2 μA, at 10 V. It is particularly notable for its stability under wide temperature variations.*

The hermetically sealed glass capsule construction adopted by the G.E.C. is now universally recognised as the only satisfactory form. No major design change has since been found necessary, although a continuous process of confinement and detail improvement has produced the stable, reliable and efficient modern product.

THE GENERAL ELECTRIC CO. LTD., MAGNET HOUSE, KINGSWAY, LONDON, W.C.2

6′ 0″ Enclosed Standard Cabinets

These superior enclosed Cabinets are available at an economical price, yet still maintain, to perfection, the excellent standard of material, craftsmanship and finish that has become a feature of the H. & H. range. These Cabinets may be used singly or, as shown below, in Unit Formation—in which case the protruding side panels are removed and the units bolted together.



Unit Formation

A Catalogue of H. & H. Cabinets, Rack and Cases, giving details of the full range, is available upon request.

See our STAND No. 141, at the R.E.C.M.F. Exhibition Grosvenor House, London. April 19th to 21st 1955

Hassett & Harper Ltd

REGENT PLACE, BIRMINGHAM, 1
Telephone: CENtral 6418 (4 lines)
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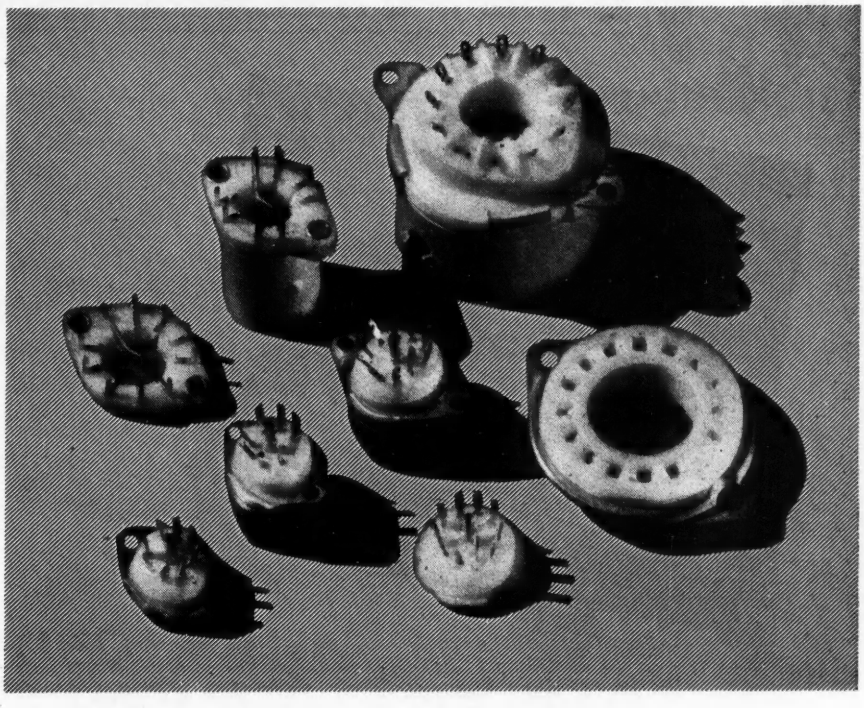
CONTRACTORS TO GOVERNMENT DEPARTMENTS

'FLUON'*

a new insulant for electronics



These valve holders, made from 'FLUON' polytetrafluoroethylene by The Edison Swan Electric Co. Ltd., demonstrate the remarkable insulating properties of 'FLUON':

Operating temperature range	– 80°C. to 300°C.
Operating frequencies	60 to 10^9 C.P.S.
Power Factor	0.0001
Dielectric Constant	2.0
Water Absorption	NIL
Non-tracking	

Can 'FLUON' solve YOUR problems?

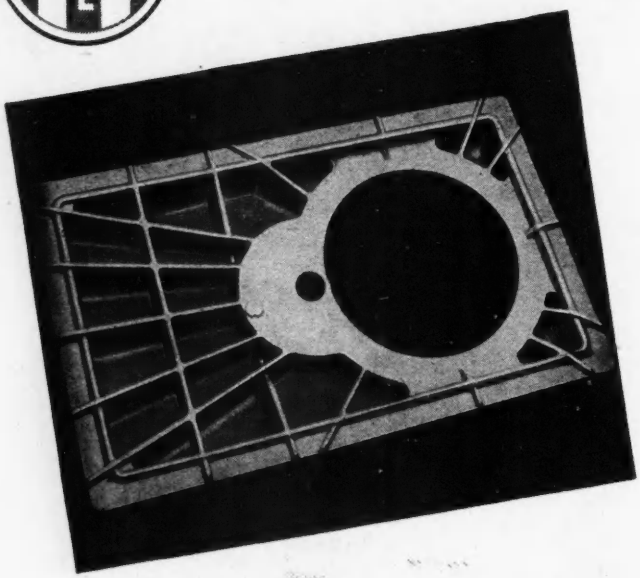
*'FLUON' is the registered trade name of the polytetrafluoroethylene manufactured by I.C.I.

Please ask for full technical data.

IMPERIAL CHEMICAL INDUSTRIES LTD., LONDON, S.W.1.

P.566

A Wide and Handsome Casting Service



Casting in Aluminium Alloy
(approx. weight 386 lbs.)

C and L Hill LTD would welcome your enquiries for Non-Ferrous Sand Castings, Brass, Naval Brass, Brazing Metal, Gunmetal, Phosphor Bronze, Aluminium Bronze, High Tensile Manganese Bronze, High Conductivity Copper, " Hilchil " Chill Cast Phosphor Bronze Bars, Cored and Solid. Sand Castings in all Aluminium Alloys. Aluminium Gravity Die Castings.

Hill facilities include

Wood and Metal Pattern Shop. Fully Approved Laboratory and Test House with Inspection Organisation. Facilities for Radiology. Specialists in Development and Quantity Production of Castings for Radar.

Design your Castings for SHELL MOULDING and save Machine Shop costs.

MEMBER OF THE OWEN ORGANISATION

You can support the B.R.M. through the O.R.M.A. (Owen Racing Motor Association) Members £1. 1. 0 per annum. Associate Members 5/-. Car Badge (full members only) £1.10. 0 extra. Full details from : THE SECRETARY, ORMA, KENT HOUSE, MARKET PLACE, OXFORD CIRCUS, LONDON W.1. Tele : Museum 8901-6

C.&L.HILL LTD

Stringes Lane, Willenhall, S. Staffs.

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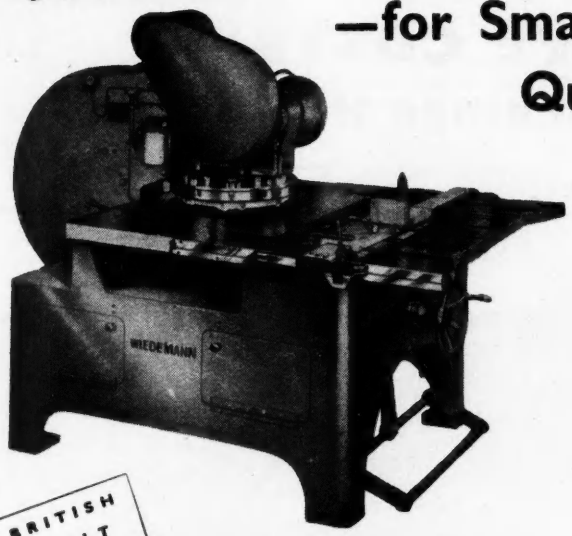
Branch Works : Wednesfield Road, Willenhall.

Both our Foundries are available for Prototype Work.

WhiteAd 3072

Fastest Piercing

—for Smaller Production Quantities



BRITISH BUILT

WIEDEMANN

Type RA-41P

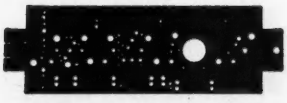
TURRET PUNCH PRESSES

give lower production costs
—than by any other method

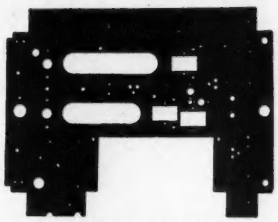
The RA-41P combines the versatility, accuracy and high speed of the pantograph for rapid hole location, with the time saving features of the WIEDEMANN Turret Punch Press for quick punch and die selection. Up to 20 low cost punches can be set up in the turret ready for instant use.

Maximum sheet size	28 in. x 40 in.
Throat depth	28 in.
Capacity	15 tons
Punching Capacity ...	3" diameter in .074" thick Mild Steel
	2" " " $\frac{1}{4}$" " " "
	$1\frac{3}{16}$" " " $\frac{3}{16}$" " " "
Strokes per minute	175

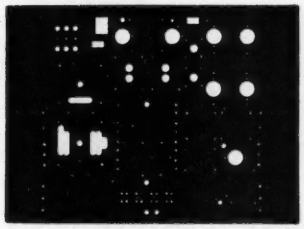
SHEET AREA UP TO 28" x 40"



OUTPUT—18 PER HOUR



OUTPUT—15 PER HOUR



OUTPUT—10 PER HOUR

ALL OPENINGS PIERCED IN TIMES SHOWN

The WIEDEMANN range includes small hand-operated models up to large power-operated machines of 80 tons capacity, capable of piercing 6" holes in $\frac{1}{4}$" plate.

Write to Sales Department for detailed Catalogue

DOWDING & DOLL LTD

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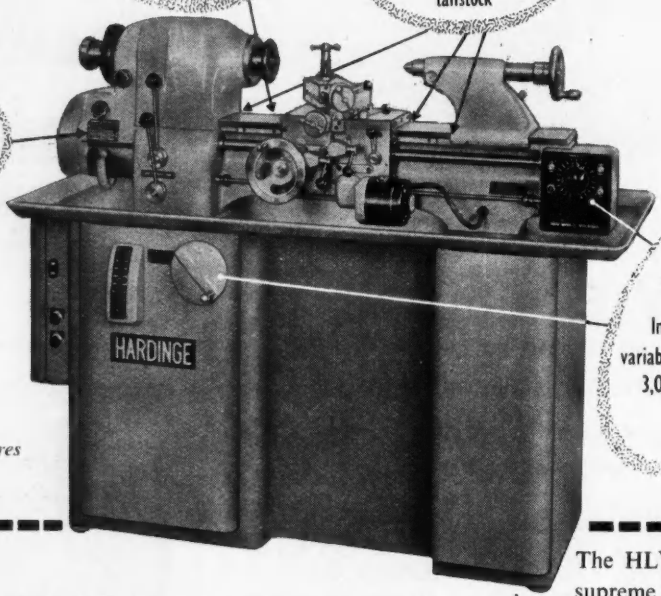
Telephone WESTERN 8077 (8 lines) *Telegrams*: ACCURATOOL HAMMER LONDON

A new idea in

SHORT RUN TURNING!

HALVE COSTS

with the Hardinge HLV Lathe



11" swing
18|20" between centres
1" collet capacity

The Hardinge HLV Lathe represents an entirely new idea for short run turning, boring and screw cutting. Ask for our mobile demonstration unit to visit you—no obligation of course.

HARDINGE
Machine Tools Limited

(One of the Sheepbridge Group)

FELTHAM · **MIDDLESEX**

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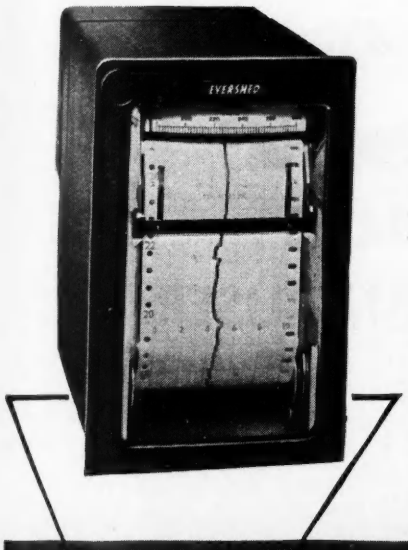
The HLV Lathe is supreme in the following fields:

- **INSTRUMENTS**
- **ELECTRONICS**
- **DEVELOPMENT**
- **SPECIALS**
- **RESEARCH**
- **RADAR**
- **TOOL ROOM**

Hardinge



WATCHING BRIEF

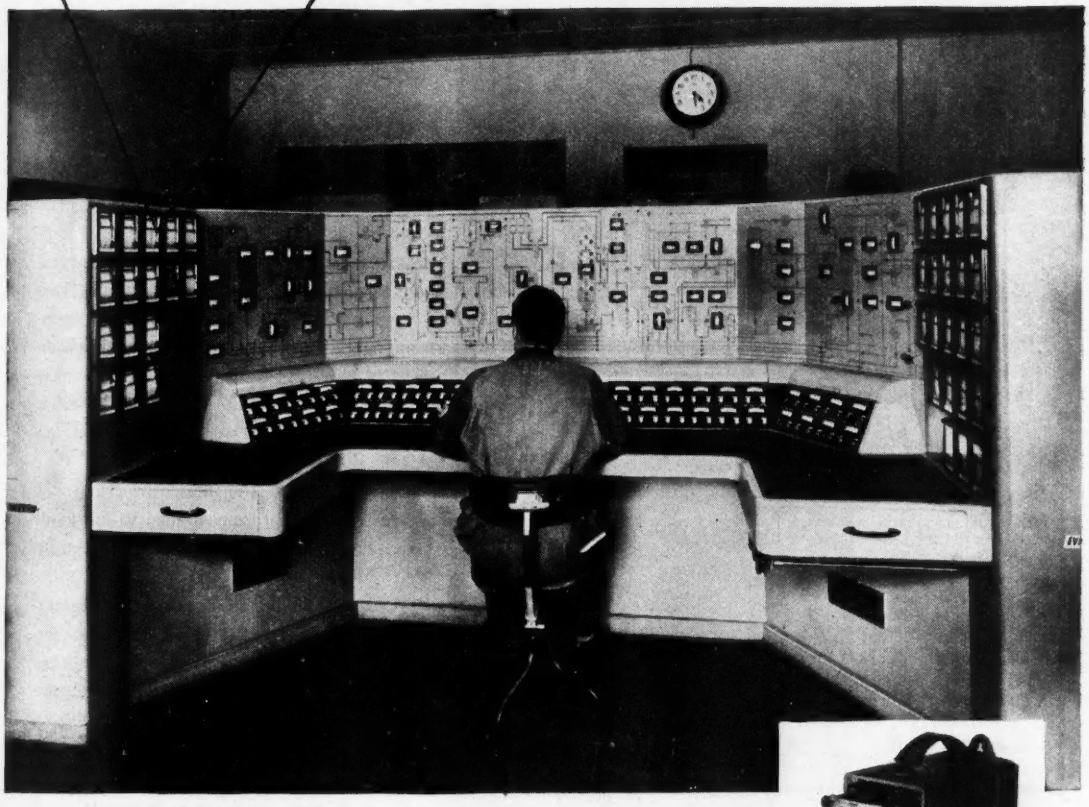
introducing the **new Miniature** Recorder by **EVERSHED**

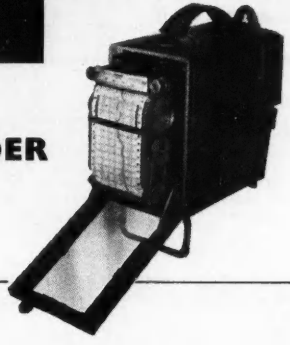
The modern trend towards miniaturisation in industrial control equipment has led to the design and development of the Evershed Miniature Recorder. Illustrated below is a Control Desk recently supplied to the Grangemouth Refinery of Scottish Oils Ltd., on which 38 recorders are fitted. They have also been supplied for the new British Petroleum Company's Refinery at Aden.

The Evershed Miniature Recorder has the maximum self-contained ranges of 500 v. or 10 amperes and will prove to be of great use to engineers and designers throughout industry. It is suitable for either flush or surface mounting or can, by the use of a leather sling, be used as a portable instrument.

Although compact, measuring only 4¼-inches wide by 6¼-inches high and 9-inches deep, the recorder will give a continuous record for one month. The movement which is of the moving coil type is calibrated to B.S. 90—1940 requirements.

FOR FULL DETAILS, WRITE FOR PUBLICATION EE 282





EVERSHED MINIATURE RECORDER

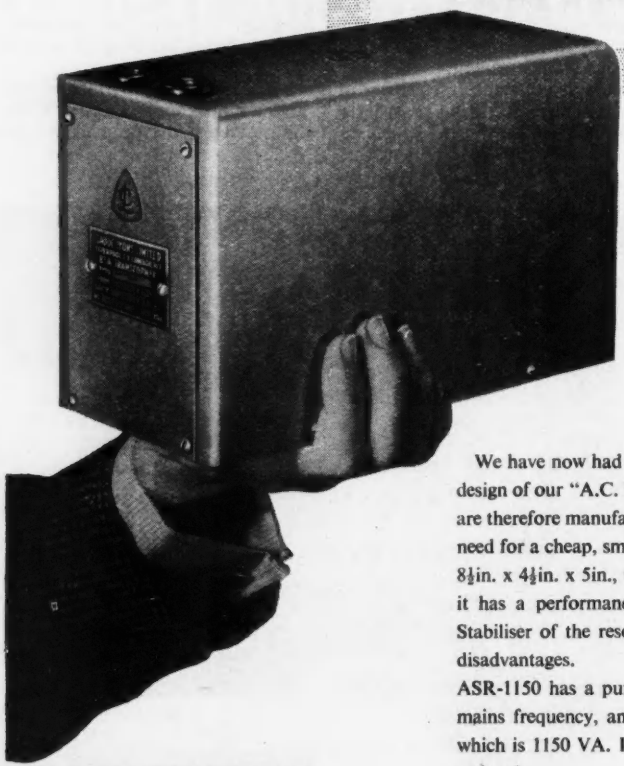
EVERSHED & VIGNOLES LTD

ACTON LANE WORKS CHISWICK LONDON W4

Telephone Chiswick 3670 *Telegrams Megger Chisk London* · *Cables Megger London*

6/154

A NEW-PRINCIPLE A-C AUTOMATIC VOLTAGE STABILISER



We have now had released to us by a Government Department the design of our "A.C. Mains Regulator, Automatic, Step, Mark II", and are therefore manufacturing this unit for general sale. It ideally fills the need for a cheap, small and light Stabiliser. Although it measures only 8½in. x 4½in. x 5in., weighs as little as 11 lbs., and costs only £24 net, it has a performance fully equal to any similarly rated Automatic Stabiliser of the resonated, saturated core type, without any of the disadvantages.

ASR-1150 has a pure output waveform, is unaffected by changes in mains frequency, and works equally well from no-load to full load, which is 1150 VA. It has a stabilised output at 230V unless otherwise ordered.

Many other Automatic Voltage Stabilisers are now manufactured by us, and all are available for immediate delivery. In some cases the constancy of output is as high as 0.15%. Models are available from 200 VA to 30 kVA, single phase. 3-Phase Stabilisers are also available. Prices are *extremely* competitive.

We can supply from stock all types of American tubes, condensers, valves, potentiometers, etc.

★ *MEMO ; If you are interested in infinitely-variable Transformers, do not forget the almost indispensable "VARIAC" (Reg'd. Trademark). Models are available from 170VA to 21kVA. Our Catalogue V-549 (3rd Edition) tells the whole story, and will gladly be mailed free and post free, on request.*

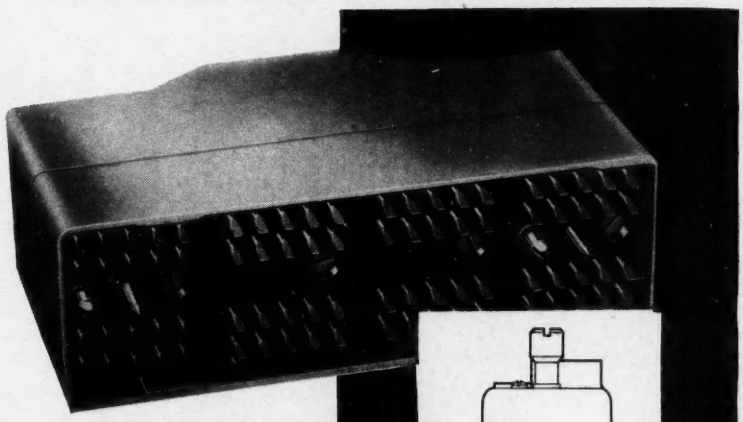
The *NEW "ASR-1150"* costs only *£24* net

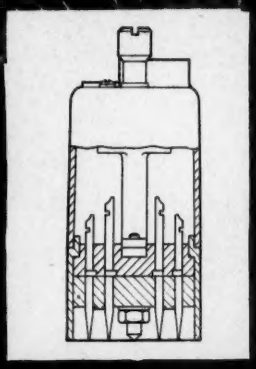
CLAUDE LYONS LTD.,
Electrical and Radio Laboratory Apparatus etc.

Head Office and Works: 76, OLDHALL STREET, LIVERPOOL 3, LANCS.
Southern Factory: VALLEY WORKS, WARE ROAD, HODDESDON, HERTS.
(A.10 main London/Cambridge Road, at Junction of A.602)

Designed with typical

Plessey *thoroughness*





A FLEXIBLE AND RELIABLE INTER-CONNECTION SYSTEM FOR MULTI-LINE CIRCUITS

A reliable, rapid and fool-proof method of inter-connection for multi-line circuits has now been achieved by Plessey Design and Development through the introduction of a range of standardised Plugs and Sockets. This innovation has made possible a unit method of construction so superior in operation that it has become standard practice within the electronic and light electrical industries. Typical examples may be seen in television transmitters, radar assemblies, telephone exchanges and railway signalling systems.

This Publication is available on request . . . if you would like further information regarding these and other multi-way connectors, Plessy Publication No. 741 is available to manufacturers free on request.

BRIEF SPECIFICATION

Working volts—250 v. D.C. — Insulation resistance 100 megohms at 500 v.

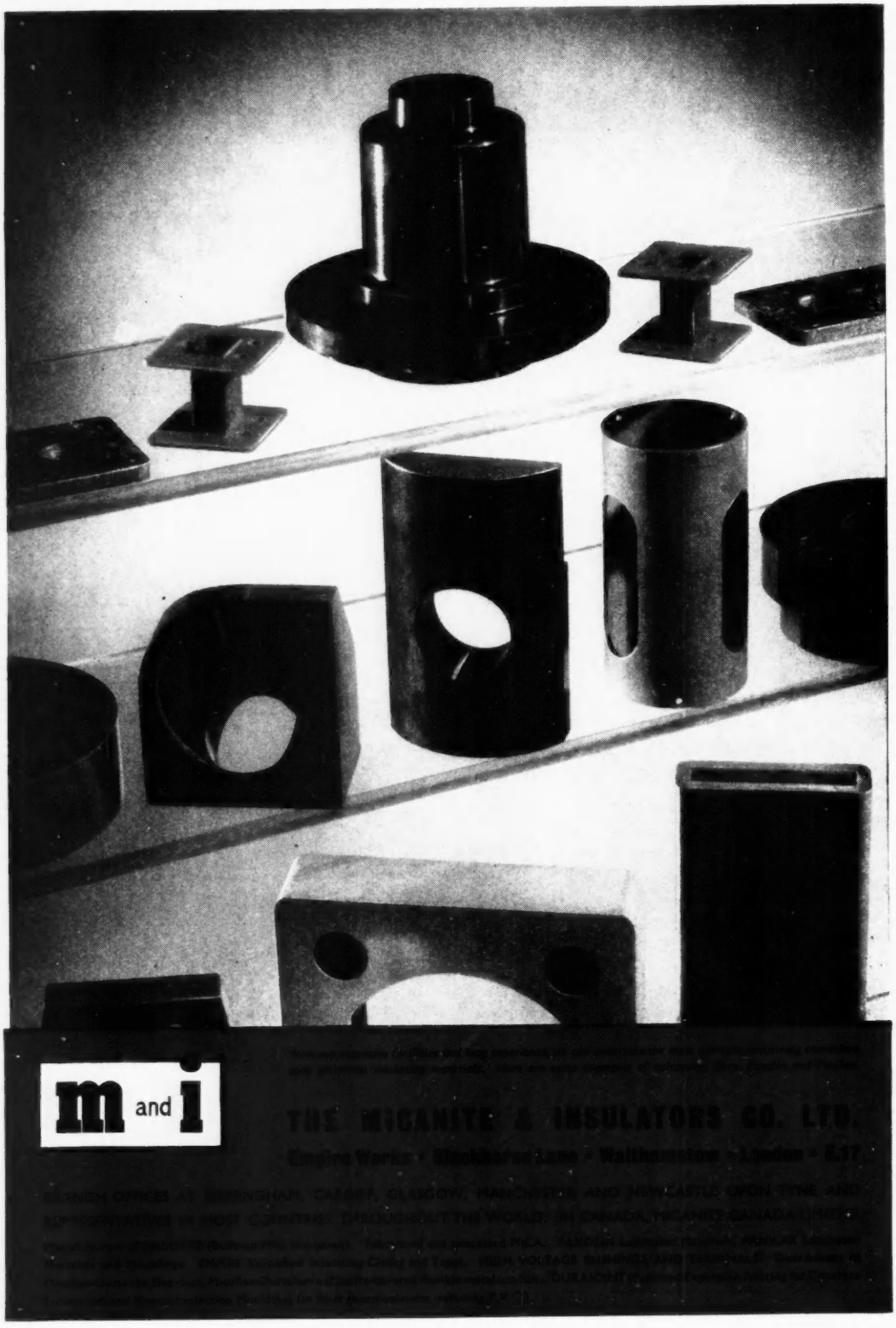
Maximum current —2 amps at 250 v. D.C. Contact resistance—1 milliohm.

Temperature range +70°C to −40°C.

The plug is secured in the socket by a central clamping screw. Cables are firmly clamped to avoid strain. Plug contacts are chisel-type blades which tend to make the plugs self-ejecting from the socket on disengagement.

THE PLESSEY COMPANY LIMITED, ILFORD, ESSEX.

PB4a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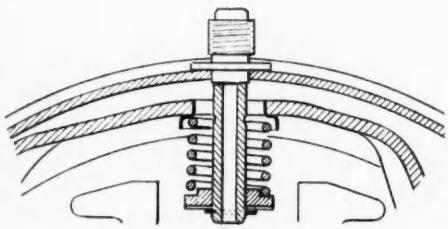
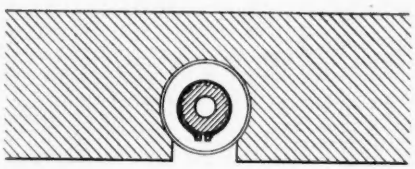
A RETAINER SAVES TIME . . . . . AND MONEY*





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☐ Send representative ☐ Letter attached

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P2

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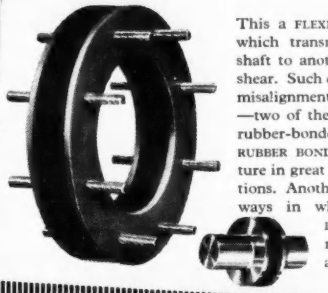

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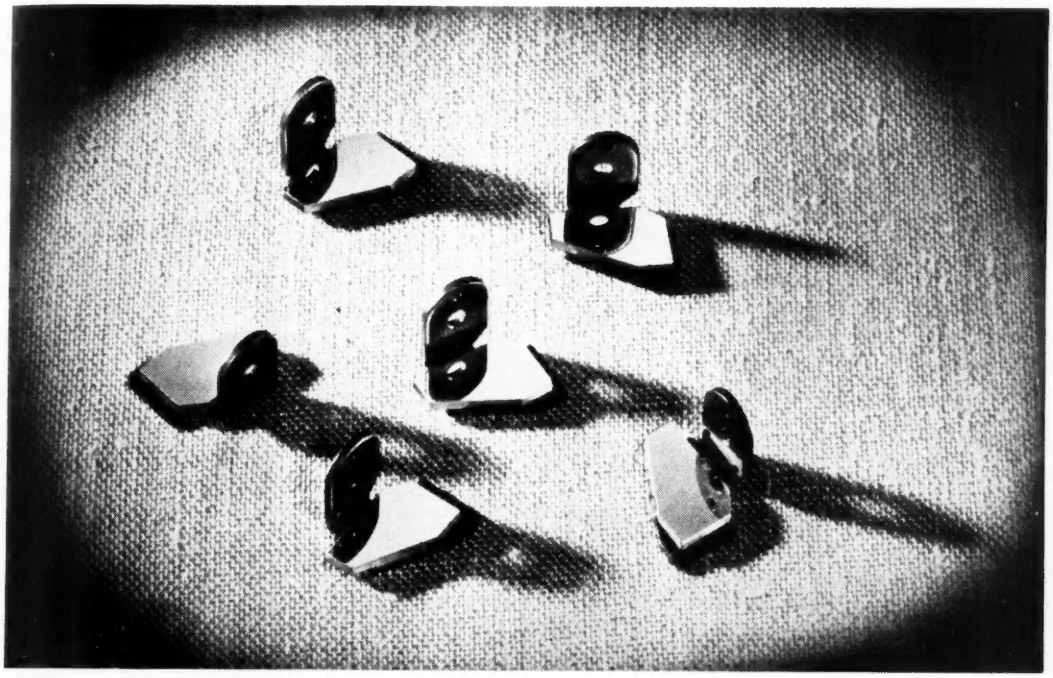
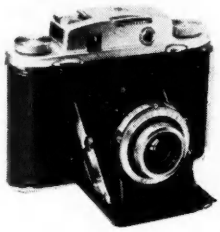
R.B. 90





A subject for reflection

A cold-setting adhesive giving a permanent, truly structural bond between dissimilar, non-porous materials has uses in almost every industry. Reflect, if you will, upon the problems of joining glass to steel to provide joints that are durable even under tropical conditions, that are resistant to chemical attack and in tests to destruction show the bonds to be unimpaired.

Our photograph is of Ross-Ensign range-finder mirrors in which glass is bonded to the steel brackets with 'Araldite' Type 101. The Production Research department of this well-known British camera manufacturer reports "'Araldite' is used because of its adhesive properties, tenacity and lack of deterioration with age."

Today, 'Araldite' epoxy resins are speeding output and solving problems of design in many industries. For strength, durability and range of applications they are unrivalled. May we send you full details?

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'Araldite' (regd.) epoxy resins are obtainable in the following forms:—

- *Hot and cold-setting adhesives for metals and most other materials in common use*
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'Araldite' *epoxy resin adhesives*

Aero Research Limited *DUXFORD, CAMBRIDGE. Telephone: Sawston 187*

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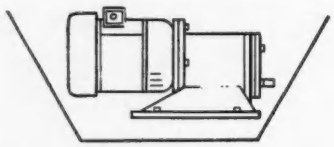

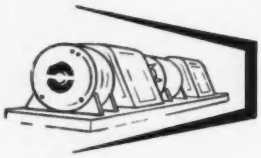

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They are all

Resistant to moisture
Chemically inert
Excellent dielectrics

I.C.I. Silicone Resins, Rubbers and Fluids ***for the Electrical Industry***

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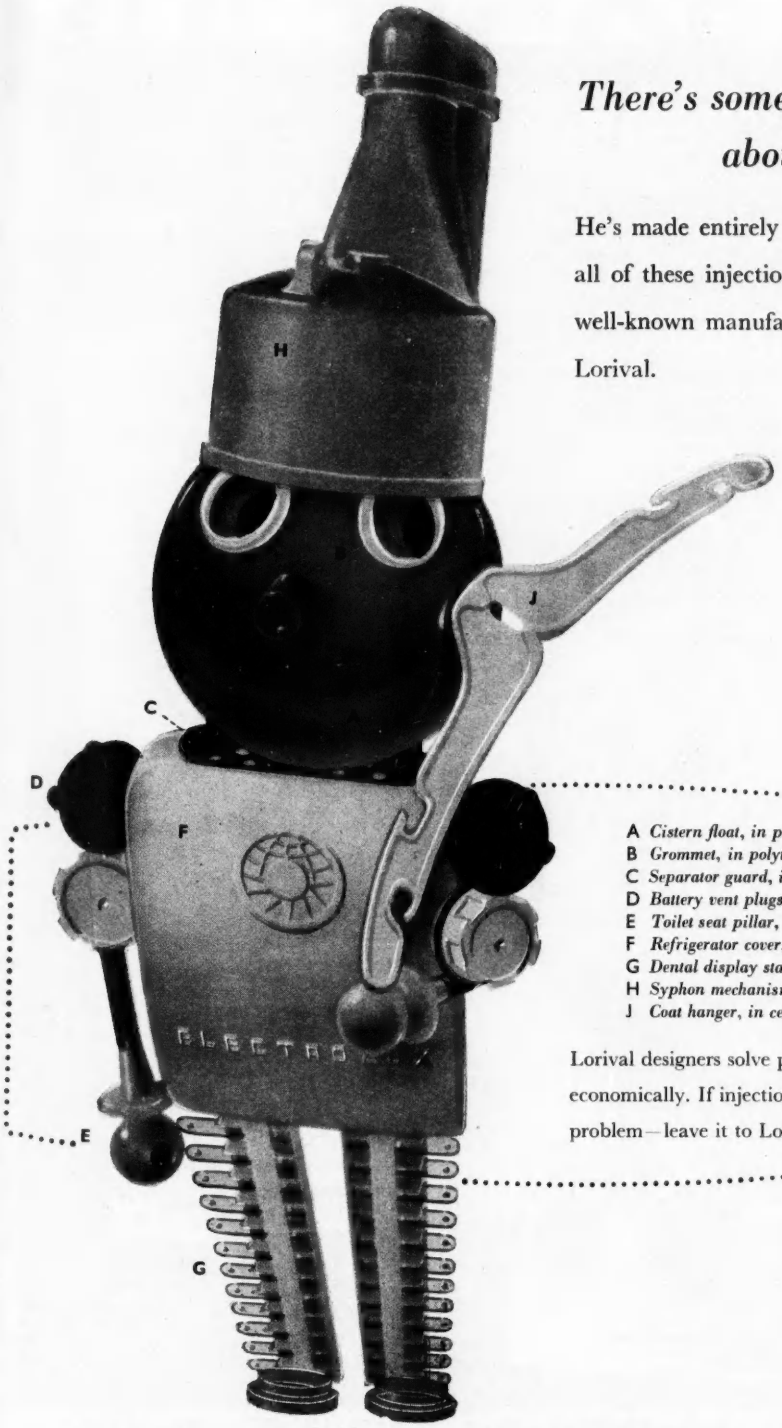

There's something about this soldier . . .

He's made entirely of injection mouldings. And all of these injection mouldings were made for well-known manufacturers by the lively lads at Lorival.

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B *Grommet, in polythene*
C *Separator guard, in polystyrene*
D *Battery vent plugs, in polystyrene*
E *Toilet seat pillar, in polythene*
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H *Syphon mechanism, in polythene*
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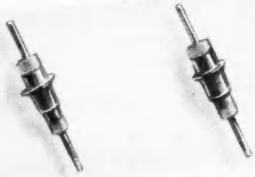
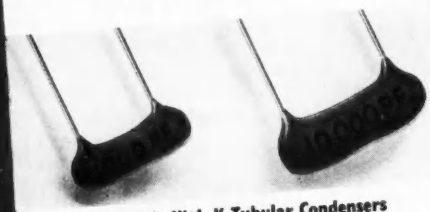
Temperature Compensating Ceramic Tubular Condensers. Positive 100. Negative 750.



Feed-through Ceramic Condensers



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200 PF. to ·01 mfd.

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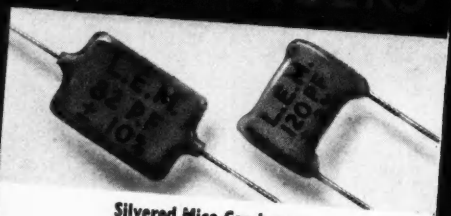

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Up to 10 kv. Test.

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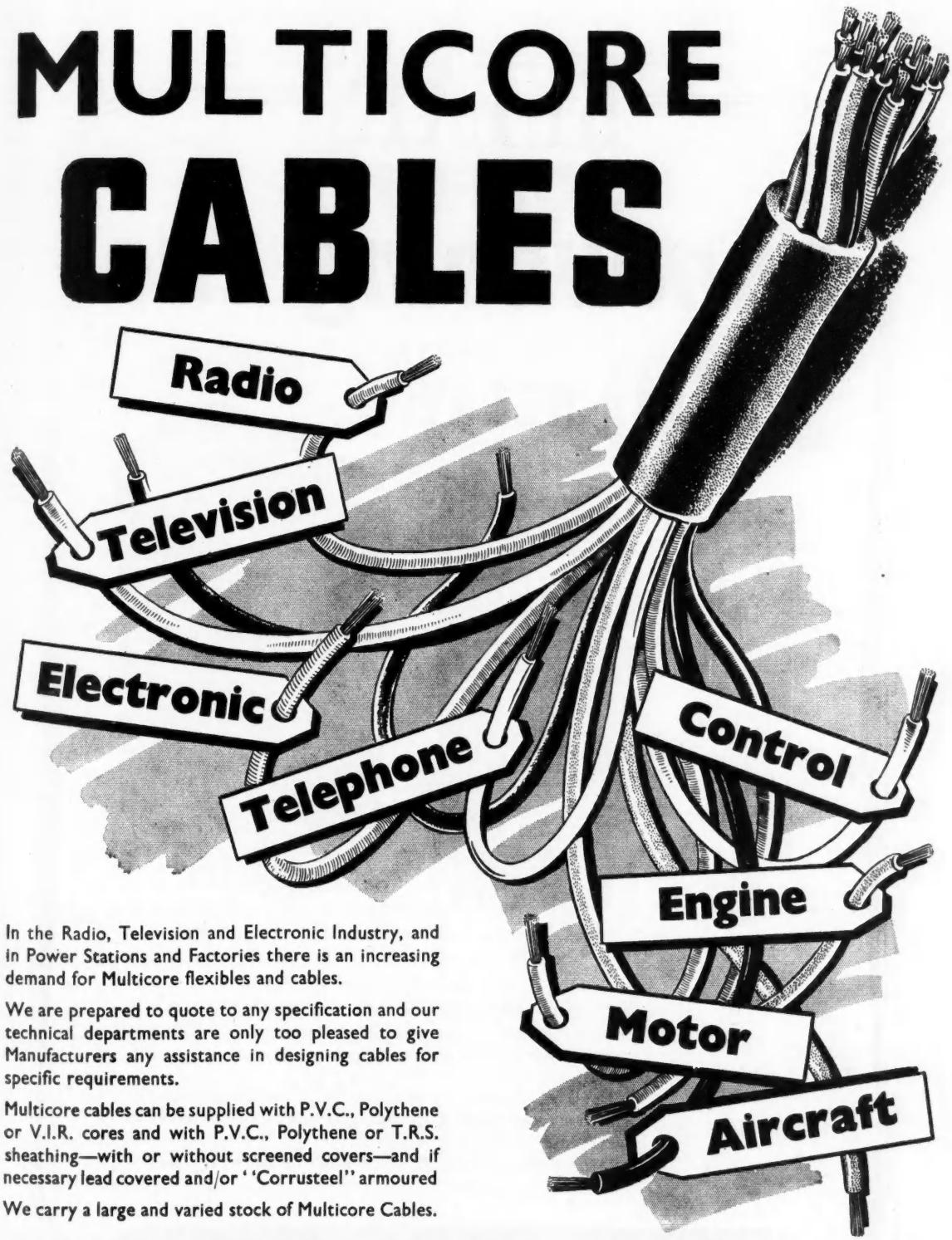
MULTICORE CABLES



In the Radio, Television and Electronic Industry, and in Power Stations and Factories there is an increasing demand for Multicore flexibles and cables.

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2400 RELAY

A Relay of noteworthy dimensions, designed in size and performance to suit present day electronic equipment. The new 2400 Relay is available with twin light duty or single heavy duty contacts.

When fitted with a 10,000 ohm coil, the pull-in is approximately 4 milli-amperes; contact pressure and clearance have not been sacrificed to achieve this sensitivity.

DIMENSIONS: Above chassis 2½" high x 1" wide x 1⅝" deep.

WEIGHT: 4½ ounces.

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The material for

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TUFNOL is an electrical insulator used extensively where mechanical service is required in addition to the provision of insulation. It is available in various brands to suit individual requirements and in the basic forms of sheets, tubes and rods or specially moulded shapes.

TUFNOL sheets can be up to approximately 46 inches square and 9 inches thick, tubes up to 46 inches long and 4 inches cross section and rods up to 46 inches long and 2 inches diameter (larger diameters available subject to special enquiries). Tufnol can be punched easily, speedily and economically and machined easily with the usual engineering tools to produce a wide variety of components. Alternatively, components may be produced to specification in the Tufnol factory.

TUFNOL complies generally with the appropriate British Standards and Specifications of Government Departments. Most brands comply with R.C.S. 1000. "Kite" Brand Sheet complies with B.S.2076: 1954 and B.S.1137: 1949. "Carp" Brand Sheet passes all mandatory and optional clauses of B.S.972: 1941. "KITE" Brand tubes comply with B.S.1314, Type A: 1946 and B.S. 1951: 1953.

Our technicians will gladly discuss your requirements on

STAND No. 129 R.E.C.M.F. EXHIBITION
Grosvenor House, London, W.1. **April 19-21—1955**

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GPO television pirate detection

Television " piracy " — non-payment of licence fees — drains revenue from national resources and limits money available for development. To combat this, the G.P.O. now have a fleet of mobile detecting units throughout the television receiving area of the country, each capable of locating the exact spot on which a television set is functioning.

A Pullin microammeter is incorporated in the detector cars' electronic apparatus, which was manufactured and installed by G. A. Priechenfried and Associates to a G.P.O. experimental design.

In common with many Pullin measuring instruments used on switchboards, in laboratories, electronic equipment, aircraft, machine tools and a host of other industrial and commercial installations, this particular microammeter has a robust movement. It gives consistently accurate readings despite road shocks and engine vibration. Its dial illumination is a design exclusive to Pullin instruments and is suitable for a 6 or 12 volt supply, making the scale easily readable, with a complete absence of glare, in the dark interior of the vehicle.

Have you the current Pullin catalogue ? It describes the complete M.I.P. range of portable and panel-mounting instruments, multi-range test sets, ohmmeters and relays.

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Supplied in four main types, summarised as follows :—

TYPE " NCC " Heavy duty type as supplied to the Services for cables subject to rough usage and exposure in severe outdoor conditions. Stands severe bending, and torsional movement. Supplied complete with required end fittings—attached specially to withstand pulling strains. Tough neoprene outer cover, or wire braided finish if desired.

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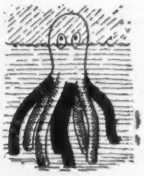
TYPE " VMC " Generally similar to type " MC " but with an additional outer cover of PVC or Neoprene which gives added protection. Electrical continuity is maintained by the tinned copper braid immediately under the outer extrusion.

TYPE " VC " A light type of extreme flexibility, covered with a smooth PVC sleeving. Electrical continuity can be maintained by means of a tinned-copper bonding wire between inner and outer covers. Standard end fittings and conduit threads.



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The D-489 MUIRHEAD-PAMETRADA WAVE ANALYSER

WITH the Muirhead-Pametrada Wave Analyser the localization of obscure vibrations can be carried out systematically. Designed specifically for such measurements, this instrument covers a range of 19*-21,000c/s with a frequency accuracy of ±0.5% over most of the range. Its high selectivity enables component frequencies close to one another to be measured; the flat top of the tuning characteristic can be varied to simplify measurements of fluctuating frequencies; and the 1/3 octave filter characteristic enables predominant vibration components to be rapidly located. In almost every branch of engineering there is a use for this novel instrument.

FEATURES

Operates as a tuned band-pass filter — *not* on the heterodyne principle.

Frequency accuracy ±½% over most of range.

High selectivity characteristic for greatest discrimination against adjacent frequencies.

1/3rd octave filter characteristic for noise measurement or rapid localization of principal vibration components.

Band-pass characteristic for measurements when frequency is fluctuating.

Output frequency is that of selected component and is available for oscilloscope viewing.

**Additional unit extends useful range down to 2c/s.*

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VIBRATION MEASUREMENT AND WAVEFORM ANALYSIS

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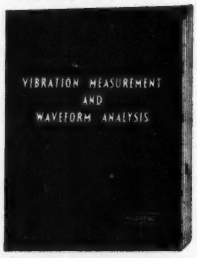

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PRECISION ELECTRICAL INSTRUMENT MAKERS

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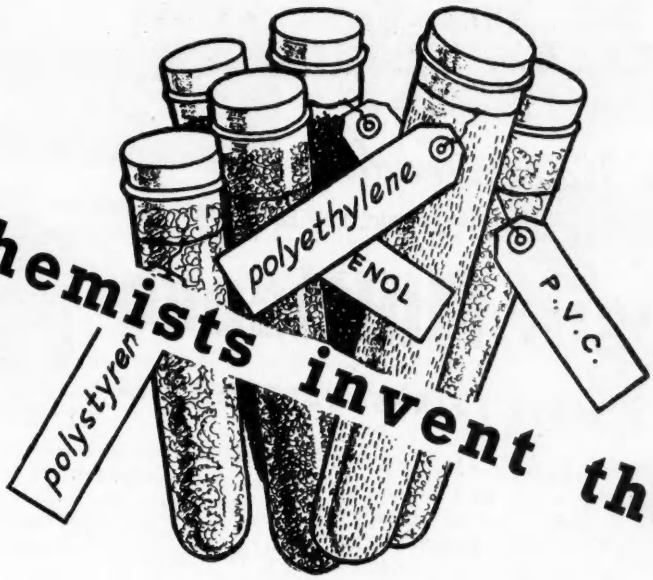

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We take all the various PLASTICS materials and by dint of long experience and, we hope, some imaginative skill, turn them into the telephone case on your desk, the radio cabinet by your fireside, the instrument panel in your car and many other familiar things. And, since our organisation is one of the largest of its kind in the world, our output is on a scale to satisfy the largest industrial enterprises

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OF TELEVISION, RADIO, TELEPHONE AND ELECTRONIC EQUIPMENT PREFER

Ersin Multicore

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THE 7 LB. REEL FOR FACTORY USE
Prices on application

For over 16 years Ersin Multicore Solder has been the choice of manufacturers all over the world. Its 5 entirely separate cores of flux prevent breaks in the flux stream; there are no wasted lengths of solder without flux and the risk of making dry joints through insufficient flux is eliminated. Savings can often be made when using Ersin Multicore 5-core Solder as an alloy of lower tin content can often by used with complete efficiency.

ALLOYS AND GAUGES

Ersin Multicore Solder is supplied in all the usual Tin/Lead Alloys: 60/40, 50/50, 45/55, 40/60, 30/70, 20/80. Other alloys are supplied to special order. Standard gauges are as follows: 10, 12, 13, 14, 16, 18, 19, 20, 22, 24, 26, 28, 30, 32, and 34 s.w.g.

FLUXES

The A.I.D. approved type 362 flux, or even faster type 366 is incorporated in Ersin Multicore 5-core Solder. The following types of flux are also available: N flux containing Pentacol; 3E flux, the original Ersin Flux formulation which has been supplied for more than 16 years; R2 and R3 fluxes, Halide and Chloride free for modern production soldering processes calling for this type; L flux, suitable for high-speed machines and particularly lamp production; 2L flux which is the same as L type but with only 2.2% flux content.

SPECIAL HIGH AND LOW MELTING POINT SOLDERS

Ersin Multicore is available in the following special alloys, all containing 5-cores of Ersin Flux.

Type T.L.C. Melting Point 145° C.

Type L.M.P. Melting Point 179°C. Avoids 'pick-up' of silver when soldering ceramics.

P.T. Melting Point 232°C. When lead-free solder is required.

COMSOL. Melting Point 296°C. Extra high melting point soft solder with or without cores of flux.

LIQUID AND JELLY FLUX

Ersin Flux is supplied in liquid form for dipping purposes when it is not possible to use cored solder. A high viscosity red jelly is now also available for processes where a flux with greater properties of adherence is required. Ersin Jelly Flux is M.O.S. approved for specific soldering purposes.

SOLID SOLDER WIRE

Multicore Precision-made Solid Wire is supplied to special order in all gauges, for the comparatively few soldering processes where cored solder is unsuitable.

PRINTED CIRCUITS

A complete soldering process has been developed by the Multicore Laboratories, including a protective coating which has been specially formulated for the tags of components to be solder dipped. Ask for Special Information Folder Ref. PCL101.

Bib WIRE STRIPPER AND CUTTER

This handy tool strips insulation without nicking the wire, cuts wires cleanly and splits plastic extruded twin flex. Adjustable to most wire thicknesses by the turn of a screw. 3/6 each (subject).

Bib RECORDING TAPE SPLICER

18/6 EACH (Subject)

This Splicer, which incorporates many new detail refinements, enables recording tape to be jointed easily and accurately so that no breaks or "clicks" in the recording are discernible.

SIZE 1 CARTON 5/- (SUBJECT)

Cat. Ref. No.	Alloy Tin Lead	S.W.G.	App. L'gth per carton
C 16014	60/40	14	21 feet
C 16018	60/40	18	55 feet
C 14013	40/60	13	19 feet
C 14016	40/60	16	38 feet

We shall be pleased to see you on Stand 69 at the R.E.C.M.F. Exhibition to answer questions about the Multicore range or show you the latest additions. If you are unable to do so, but would like up-to-date information, please get in touch with our Technical Service Department, who are at your service to help in solving any soldering problems.

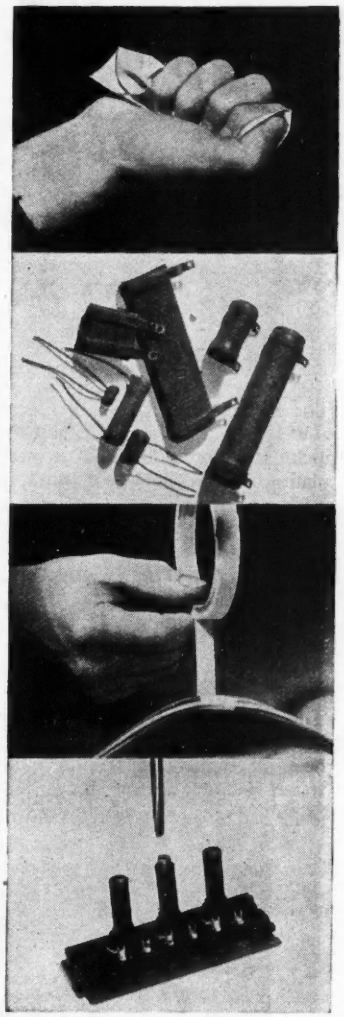
MULTICORE SOLDERS LTD., MULTICORE WORKS, HEMEL HEMPSTEAD, HERTS · (BOXMOOR 3636)

LATEST NEWS

Recent Multicore developments include the introduction of SAVBIT alloy which increases the life of soldering bits approximately 10 times.

NEW, HEAT-STABLE, WATER-REPELLENT

SILICONE INSULANTS



A NEW, LOW-LOSS, ELASTIC INSULATING MATERIAL

Silastomer* 132 is a new stock for coating woven fabrics from solvent dispersion. Silastomer 132-coated glasscloth is extremely flexible and is available from 0·004 in. thick. An initial high electric strength shows no decrease after nine days at 250°C. Silastomer 132 dispersion is also used for coating electronic components. *Send for Silicone Notes K 17.*

SILICONE RESIN-BASED CEMENTS

These cements are ideal for coating wire-wound resistors and similar components. These coatings are easily applied and processed and will withstand operation up to 250°C. They show excellent resistance to moisture. *Send for suggested formulations; Silicone Notes L 21.*

(Photograph by courtesy of Erie Resistor Co. Ltd.)

SILICONE PRESSURE-SENSITIVE ADHESIVES

These new adhesives retain their bond strengths from –55°C to 250°C and have good dielectric properties. They adhere to metals, polythene, polyester resins, P.T.F.E., silicone components and, in fact, to all solid materials. Uses: pressure-sensitive tapes, bonding agents for fabricated parts. *Send for Silicone Notes L 22.*

CORE-RETAINING COMPOUND F 4001

A thick silicone grease specially developed for locking iron dust cores and other electronic components. F 4001 shows little change in consistency from –50°C to 200°C. *Send for Silicone Notes C 23.*

(Photograph by courtesy of E. K. Cole Ltd.)

Silicone Insulation Materials include varnished glasscloth and sleeving; glass/mica, glass/asbestos, micanite, glasscloth and asbestos sheet and tubes; Silastomer tapes, cloth and sleeving; enamelled winding wire and insulated cables. *For suppliers ask for Silicone Notes C19.*

* Registered trade mark of Midland Silicones Ltd.

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(associated with ALBRIGHT & WILSON LTD. and DOW CORNING CORPORATION)

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Renovating the zinc protective coating of a propeller blade on site at Air France.

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Gold	2,000	100	6.2
Indium	4,000	<1	2.5
Iron	3,000	175	10.2
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Nickel	5,000	500	5.1
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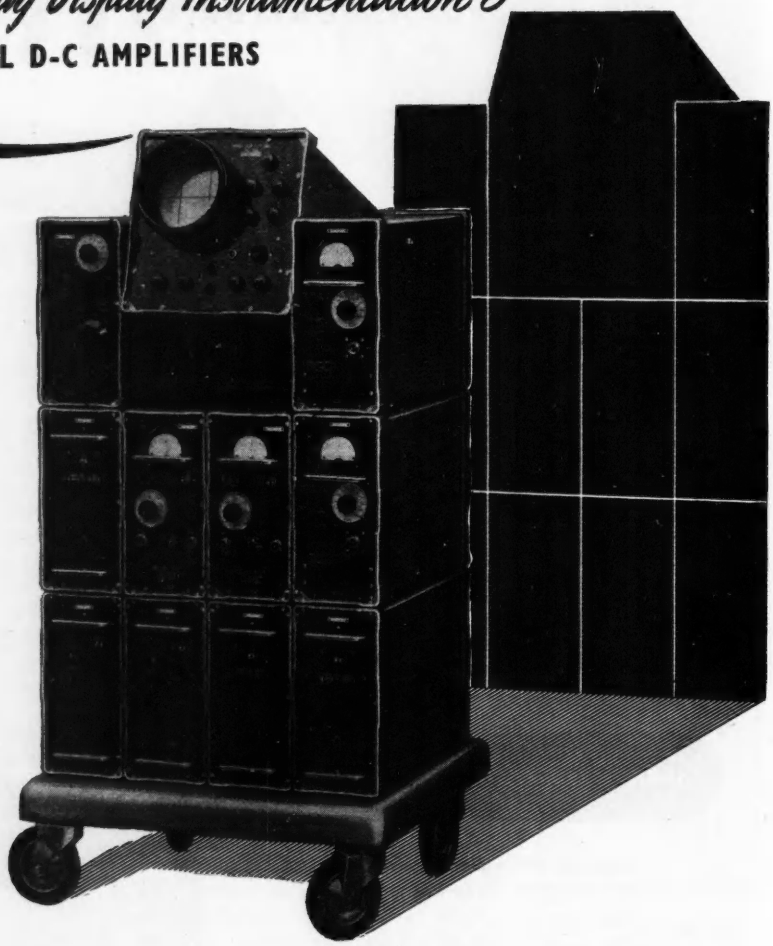

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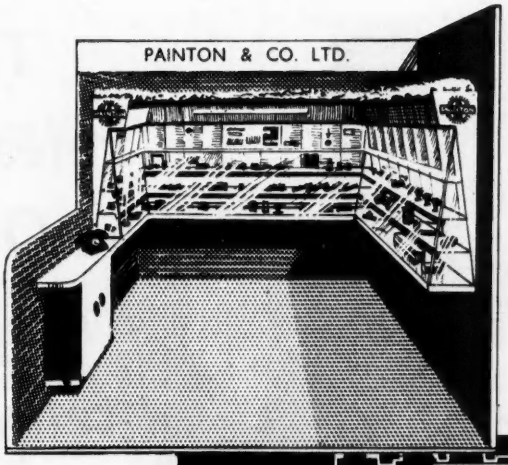

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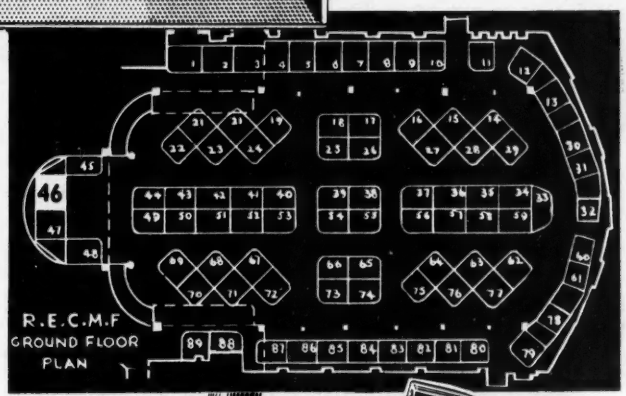

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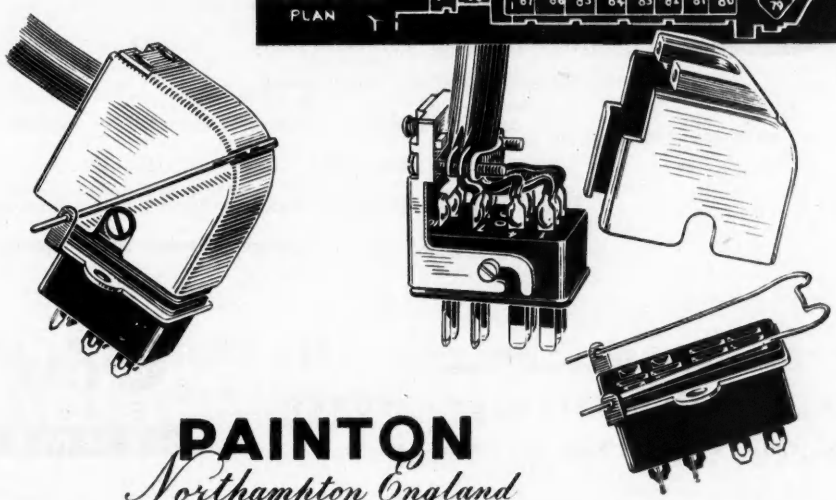

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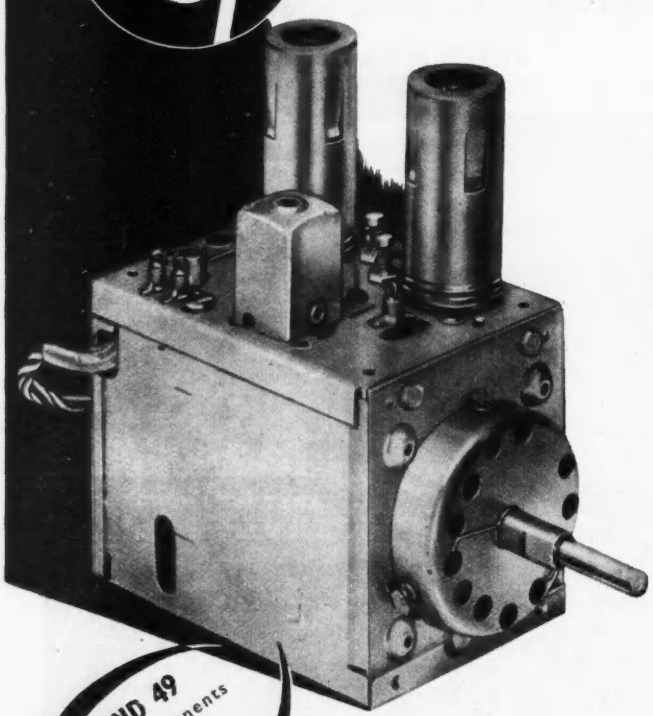

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Electronic Engineering

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Managing Editor H. G. Foster M.Sc. M.I.E.E.

Vol. 27 APRIL 1955 No. 326

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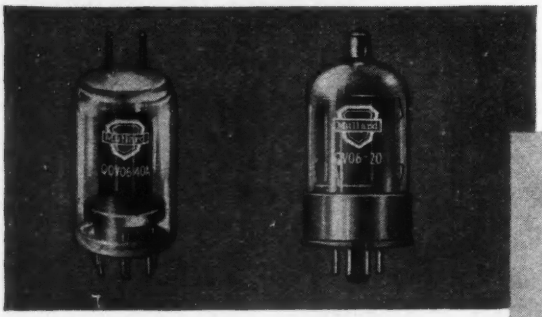

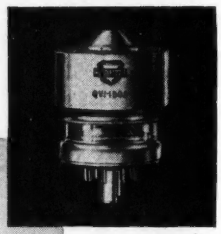

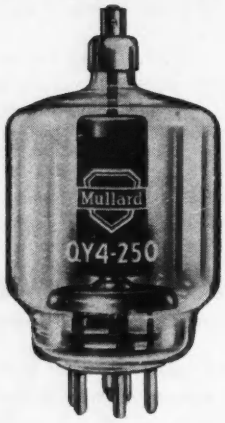

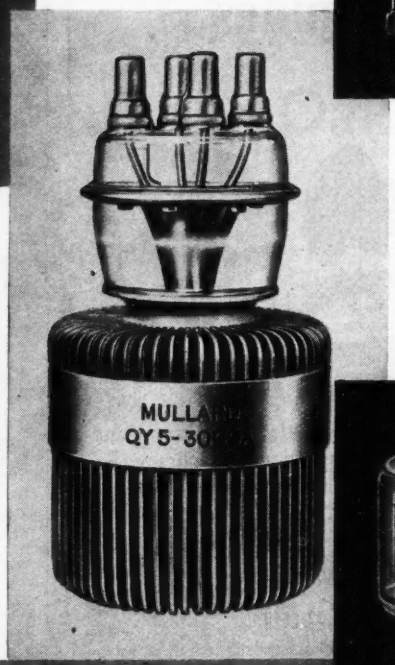

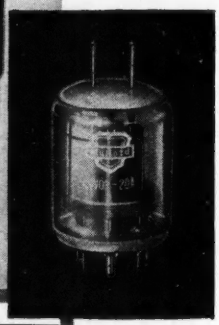

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QV06-20	6146	CV3523	V.H.F. Power Tetrode	Octal	6·3	1·25	600	20	42 20	60 175
QQV03-20A	6252	CV2799	V.H.F. Power double Tetrode	B7A	6·3 12·6	1·3 0·65	600	2x10	39 15	200 600
QQV06-40A	5894	CV2797	V.H.F. Power double Tetrode	B7A	6·3 12·6	1·8 0·9	600	2x20	72 45	200 500
QY3-125	4-125A	CV2130	V.H.F. Power Tetrode	B5F	5·0	6·5	3000	125	300	120
QY4-250	4-250A	CV2131	V.H.F. Power Tetrode	B5F	5·0	14	4000	250	800	75
QV1-150A	4X-150A	CV2519	V.H.F. Power Tetrode	B8F	6·0	2·6	1250	150	156 112	165 500
QY5-3000A	6076	—	V.H.F. Power Tetrode	Special 4-pin	6·3	32·5	5000	3000	3300 *3500	75 220

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ELECTRONIC ENGINEERING

VOL. 27 No. 326

APRIL 1955

Commentary

THE demand for coal has risen rapidly during the past years and one cause has been the increasing demand for electrical energy. Figures recently published by the British Electricity Authority show just how phenomenal has been the demand for electrical energy in this country.

From a mere 5 600 million units in 1925 the annual demand rose to about 30 600 million units in 1945—a five-fold increase in twenty years. The growth has continued in the post-war years and at the end of last year the demand was about double the 1945 figure—some 60 000 million units. Yet the end is not in sight, for it is estimated that in 20 years' time the demand will be some 3½ times the present level.

Practically all this energy is produced by the coal fired power stations and unless some alternative source of energy can be found, and found quickly, the prospects of Britain's survival as an industrial power would indeed be very bleak.

Not a moment too soon, therefore, comes the announcement of the Government's plans to build twelve nuclear power stations during the next ten years, with a total capacity of 1½-2 million kilowatts, and at a cost of some £300 million.

As is already known, an experimental power station is in the course of construction at Calder Hall in Cumberland, at a cost of £15-£20 million, to produce electrical power on a large scale from this new source, and this station will form the basis of the design of the future nuclear stations.

During the next ten years two types of reactors are likely to be brought into use on a commercial scale. The first—an improved version of the Calder Hall (gas cooled) type—could be designed and brought into operation within the next four years. This type will burn only a small proportion of the natural uranium as fuel but will produce, as well as heat, the valuable by-product of plutonium.

The second type of reactor will almost certainly be liquid cooled and will be more efficient in that it will produce more heat from the same amount of fuel than the gas cooled type, for the same capital cost.

It is proposed that constructional work will start on two stations of the Calder Hall gas cooled reactor type in 1957 and that they will be in operation during 1960-61. These will be followed by two more stations using improved gas cooled reactors in 1958-9 to be completed in 1963 and the four stations will have an output of from 400 000 to 800 000 kilowatts.

The second stage of the construction of the remaining eight stations, probably with liquid cooled reactors, will start in 1960 and, when completed in 1965, will have an installed capacity of well over 1 million kilowatts.

The stations will be built by private industry for the Electricity Authorities who will own and operate them, but the Atomic Energy Authority, as the only body with the necessary experience, will be responsible for giving technical advice on the nuclear plant, since British industry as yet has no experience of nuclear technology.

* * *

Two men, each of whom has, in his own way, made outstanding contributions to the advancement and understanding of our science, have died recently.

One—an American—was a brilliant mathematical physicist while the other—British—was of lesser education yet possessed of an extraordinary inventive mind.

George Ashley Campbell who died in November of last year, joined the American Bell Telephone Company in 1897 at a time when the problems of telephone transmission were little understood. He had just returned from four years of study at various universities in Europe and his first task was to find some method of reducing the attenuation of telephone lines.

Familiar with the work of Heaviside, Campbell was able to develop the theory of loading, but there followed one of those coincidences, which all too frequently happen, in which the same result was arrived at simultaneously by another investigator—in this case Professor Pupin, at Columbia University. Pupin was adjudged the originator on the basis of earlier conception but Campbell pursued his studies on loaded lines and eventually arrived at the electric wave filter which was perhaps his greatest contribution. It opened the way to the carrier current system of telephony and from this has developed the multi-channel radio telephone and carrier systems of today.

Donald Macadie who died in February of this year had none of the brilliant academic background of Campbell. Born in 1871 in Scotland, he came to London at an early age and joined the Edison Bell Phonograph Company, later transferring to the National Telephone Company. When the latter firm was absorbed by the Post Office he was given an appointment at the Birmingham Post Office Factory and he remained with the Post Office until his retirement in 1935.

Macadie had a remarkable inventive ability and he produced a number of ingenious devices which are now in common use throughout the world. He was largly responsible for the design of a machine used to sort out the millions of Postal Orders returned after cancellation and, in addition, he developed an automatic coil winding machine of great flexibility which formed the basis of the present day designs.

Yet his fame probably rests on what is by comparison a much simpler device—namely the first combined multi-range ammeter voltmeter and ohmmeter which subsequently became known as the Avometer.

A High-Speed Revolution Counter

By E. L. Harrington*

The instrument described herein has been designed for measuring the rotational speed of gas turbine engines to within ± 1 rev/min at 20 000 rev/min. It operates by counting a frequency proportional to speed over a one second sampling period, and at sampling intervals of three seconds. An unusual feature of the equipment, apart from accuracy, is the flexibility of the control unit.

THE progress of engineering has always been largely dependent on new instrumentation techniques. With the arrival of the turbine in aero engines, there has been a call for more accurate and faster response instruments with wide ranges of measurement. On the particular problem of rotary speed measurement many papers have been published[1,2,3]. For research gas turbines and compressors running at high speeds, where the characteristic of thrust against speed lies between a cubic or quintic curve it is important to know the speed accurately.

Consideration of Techniques

A specification for the instrument to meet all research requirements would read as shown in Table 1, columns (a) and (b).

TABLE 1.

(a) PERFORMANCE PARAMETER	(b) DESIRED	(c) PROPOSED
Reliability ..	Absolute	Good
Accuracy ..	Absolute	± 1
Range ..	0 to 20 000 rev/min	1 000 to 20 000 rev/min
Response ..	Instantaneous	Within 3sec max
Answer ..	Direct reading	Direct reading
Display ..	(In duplicate if required)	(In duplicate if required)
Recording ..	Photographic	Photographic With camera synchronizing contacts
Simplicity of operation ..	Fully automatic	Fully automatic
Simplicity of technique	Absolute	Not very simple
Simplicity of construction and maintenance ..	Absolute	Fairly good
Ground/Flight operation	Both	Either

The decision on measuring techniques was settled by the accuracy requirement. Counting is the only practicable method which approaches absolute accuracy for measuring a continuously variable number. Having decided on a counting technique using Dekatrons[4,5], the remainder of the proposed specification was largely predetermined.

Some consideration remains for the automatic operation of the equipment in order to relieve a flight test observer of added responsibility, and on the ground to avoid inept operation. Laboratory experiments showed that it was possible to read a random 5-digit number displayed on Dekatrons in 2 seconds, but impossible to do this in 1 second. Since the number to be displayed would not be random, but invariably have a pattern such as 12579, 12581, 12582, etc., with probably only the last two digits varying, a 1·8sec reading or display time was allowed. This with a 0·2sec reset period, and 1sec counting period, gives a 3sec duty cycle for the instrument, and accounts for the "3sec maximum" response time in Table 1, column (c).

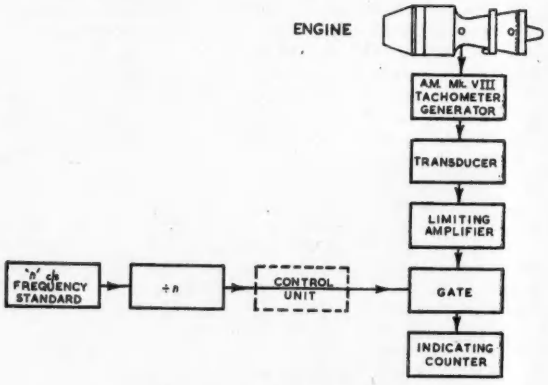


Fig. 1. Basic frequency counter

The Functional Diagram

The simplest form of revolution counter is shown in Fig. 1. It employs a timing standard of nc/s followed by a scale of n divider which produces 1sec timing pulses These timing pulses open and close a gate, thus controlling the flow of signal pulses from a source or transducer device, to an indicating counter. There is no provision for resetting the indicator, nor for adjusting the duty cycle. To perform these two functions, a control unit is inserted between the scale of n divider and the gate.

A particular control unit function is defined by Fig. 2. The unit receives two trains of 1p/s signals on separate channels, the pulses on channel A being delayed by 0·2sec from those on channel B. Pulses on channel A operate a three-state circuit and are also fed to switch the gate. The three-state device and a following time delay together block off one pulse out of every three applied to the gate; it is arranged for the gate to be open for one second and shut for two seconds. It should be noted that the exact value of the time delay is not at all critical, and hence a slugged relay will suffice. Reference should be made at this point to the timing sequence diagram in Fig. 3.

* *The Bristol Aeroplane Co. Ltd.*

The pulses on channel *B* are fed to a circuit which is required to provide the reset signal to the display unit at 0·2sec before a count period. The reset circuit is held quiescent until the one-second period before the count period. It thus ignores the triggering pulses on channel *B*. When the three-state circuit is in the condition immediately preceding the count period, it prepares the resetting circuit for action. This action is triggered by the channel *B* pulse, and is only possible when a channel *B* pulse occurs during the "reset" condition of the three-state circuit. In the foregoing it has been assumed that the pulses in channels *A* and *B* are perfectly synchronous and lack coincidence by 0·2sec. This is so, and is simply achieved, as shown later.

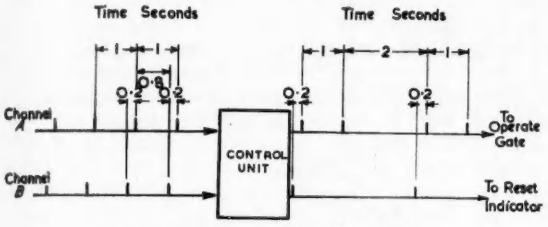


Fig. 2. Definition of control unit function

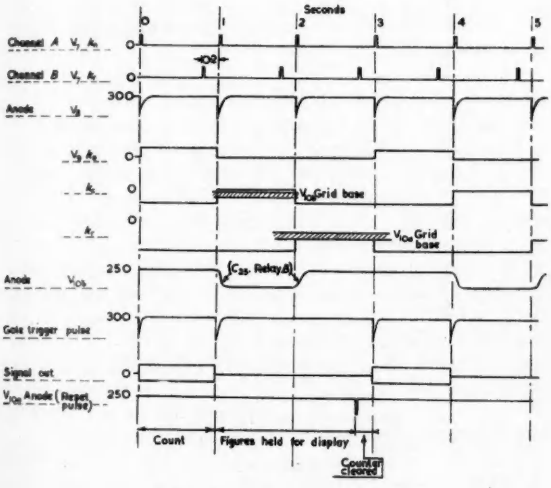


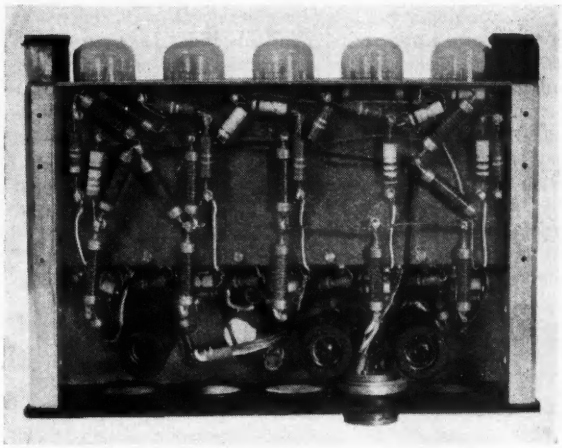
Fig. 3. Timing sequence

Detailed Circuit Techniques

The circuit diagram is shown in Fig. 4.

A 1kc/s crystal was chosen as a frequency standard. This permits direct scale-of-ten dividing to derive the 1sec timing pulses. The crystal is not temperature controlled, but has been cut to give an accuracy of 1 part in 20 000 at 20° C. By suitable padding with negative temperature coefficient capacitors it is estimated that the error due to the crystal can be made negligible over a temperature range of +40°C to −60°C.

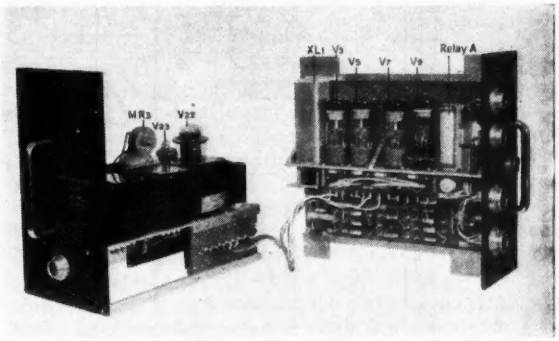
The last stage (V_7) of the scale-of-1 000 divider uses a valve type GC10/4B, which is capable of giving an output at the 8th and 10th input pulses. Thus the 8th output cathode k_7 provides the channel *B* pulse 0·2sec before the 10th cathode k_0 provides the channel *A* pulse.

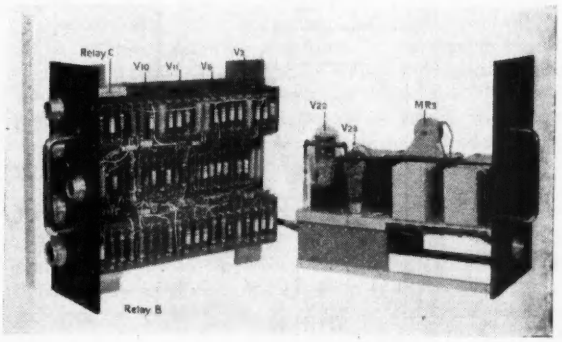


The indicator unit showing the counter tubes at the top

A valve type GS12C is used as the three-state circuit V_9. This valve has 12 output cathodes, every 3rd one being commoned, to form three groups of four cathodes. The k_0 cathode circuit, R_{19}, simply forms a waiting period while the count is in progress. The next, k_6, cathode circuit in time (and position), R_{53}, raises the grid potential of V_{10b} causing it to conduct heavily and energize relay *B*. This relay removes the trigger pulse from V_8 to the gate pair V_{12}, V_{13}, and since the relay has a delayed release, the gate misses the pulse which it should receive at the instant V_{10b} is de-energized. The gate is left shut, V_{12} cut off, and the

Two views of the control and power units





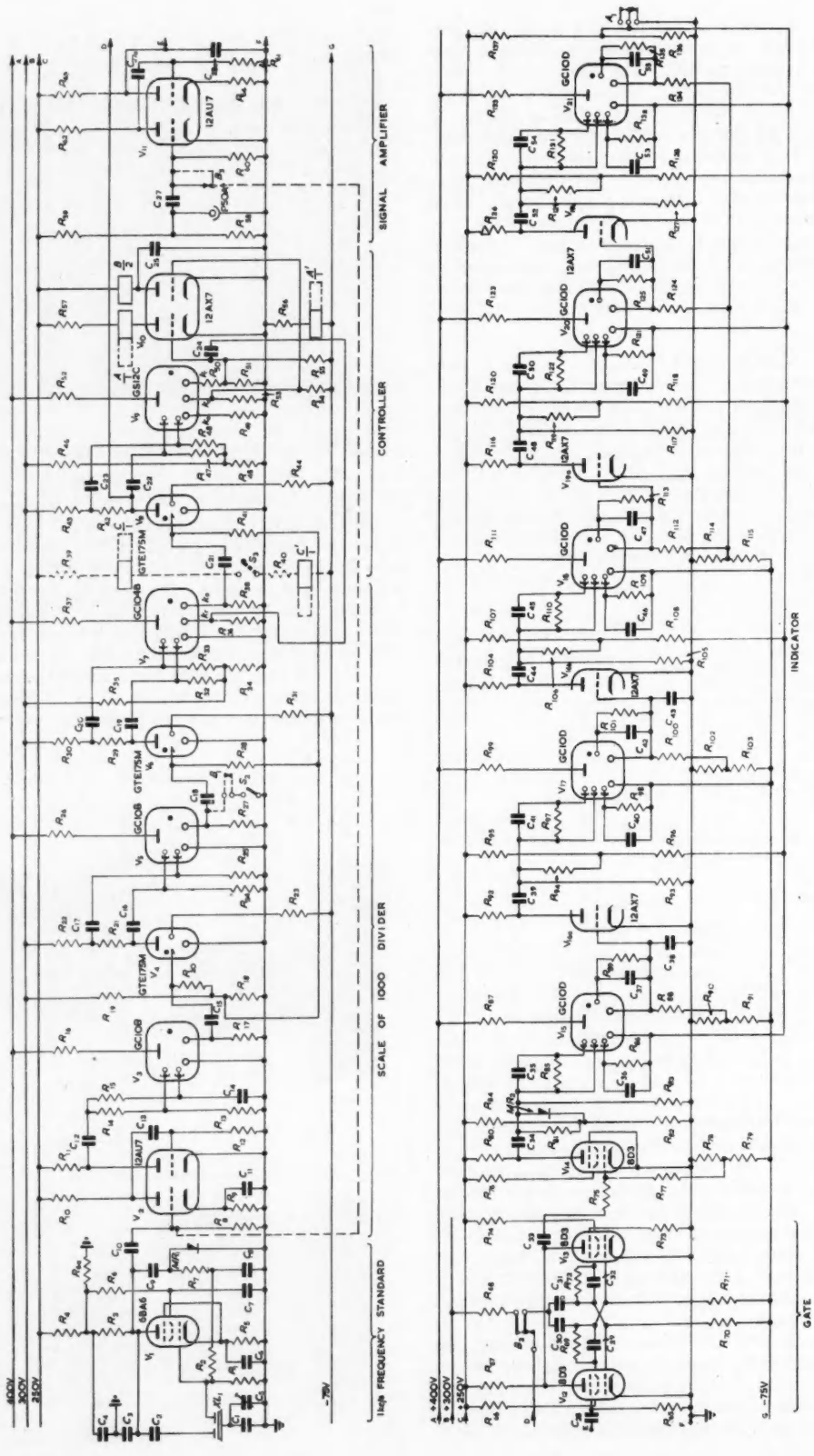


Fig. 4. The revolution counter

GS12C (V_9) third cathode circuit, k_T, is now energized, R_{58}, R_{81}. The 3rd cathode of V_9 now raises the grid of V_{10a} to the point of conduction. V_{10a} does not conduct until it receives the *B* channel pulse, 0·8sec after it received the preparation signal from V_9. This time is also 0·2sec before the preparation signal disappears. Thus V_{10a} is caused to conduct heavily for a time of much less than 200msec, and in doing so energizes the operating winding of relay *A*. One pair of relay *A* changeover contacts remove an earth from the guide bias circuits and common cathodes of all the GC10D indicating Dekatrons, and take these electrodes to a positive potential. The glow discharge can then only be maintained on the output cathodes of the indicator Dekatrons.

The function of relay *B* is not only to block off every third-gate operating pulse. It is also the "camera" relay, one pair of contacts, not shown, being brought out to a socket and providing a camera synchronizing signal at the correct time in the duty cycle.

Two modifications were introduced to the basic design in the light of customer experience. One of these was a test switch, S_3, which removes the signal produced by the transducer and supplies in its place the 1kc/s frequency standard to the gate circuits. The other modification is a "hold" switch, S_2, which in series with a pair of relay *B* normally open contacts, short-circuits the output of V_5 in the second division stage of the control unit divider. Thus when S_2 is operated and the "camera" relay made the cyclic controlling sequence will stop with the latest result displayed on the indicator.

Starting Sequence

The foregoing operation sequence will only be performed if it starts in the correct manner, i.e. if the sequence starts on the "wrong foot" then the gate may be open for two seconds instead of one. To fulfil the requirements of a correct sequence, two conditions are necessary, and sufficient, viz, the gate must be shut and the GS12C (V_9) three-state circuit must be in a corresponding position. The gate is held shut when its power supply is energized, by asymmetry of the grid resistors, R_{70}, R_{71}, the former being made lower to ensure that V_{12} is cut off. The start condition of V_9 is that the glow initially occurs on cathode k_c, R_{53}, since this cathode is highly negative. When the glow of V_9 invests k_c, V_{10b} conducts and holds off any random disturbances to the gate pair.

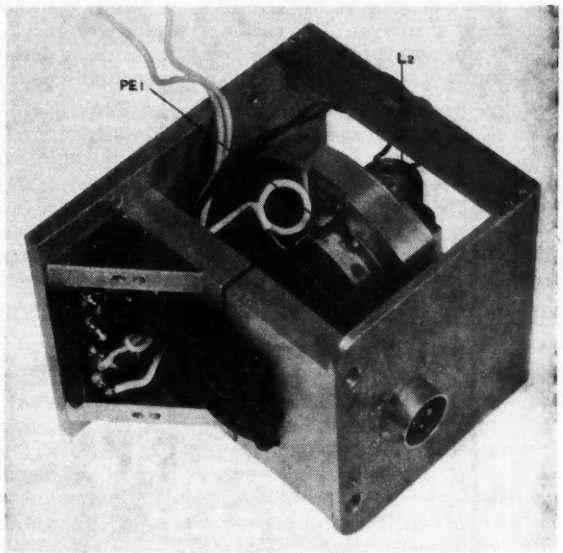
It is worth noting at this stage that the control unit is of such a form that the three-state circuit, V_9, may in fact have any number of states within the valve limitations, i.e. three to twelve. Also the duration of the states of V_9 may be simply altered by changing the cathode connexions on the valve itself. A proposed development of this instrument in order to read 100 000 rev/min will have a six-second counting state, a three-second display state, and a one-second reset state. This will be achieved by plugging into the socket now receiving V_9 (GS12C) an appropriately connected valve type GS10C.

The Transducer

In order to measure a speed of *n* rev/min to an accuracy of ±1 and use a sampling period of one second, it is necessary to generate *n*c/s at *n* rev/min. Hence the transducer or tachometer generator must generate 20kc/s at an engine speed of 20 000 rev/min.

Aero-engines are normally fitted with a three-phase tachometer generator which runs at either ½ or ¼ engine speed from an accessory gearbox. These generators drive sets of tachometer indicators which are used for approximate indication of speed. The tachometer indicator consists in part of a synchronous-induction motor, i.e. a three-phase motor with a permanent magnet rotor and a copper cage. Such a construction gives the good starting characteristic of an induction machine, and a synchronous running characteristic.

To form a suitable transducer, such a motor unit was taken, and fitted with a disk having 240 peripheral slots. The factor 240 is comprised of 4 (for the engine gearbox) times 60 (pulses per revolution). The slots are each about 0·018in wide, and light from an ordinary 2 watt dial light is focused on to them by a single



The transducer assembly

lens. A germanium photocell receives the gated light, and produces a sinusoidal signal of about 2V peak-to-peak at all conditions. Some modulation of the signal envelope is inevitable, and is composed of about 10 per cent at 100c/s and some 5 per cent at disk frequency, the latter being due to irregular cutting of the slots. Since the signal is finally limited this modulation is of little consequence. The major difficulty anticipated was that of hunting of the motor when attempting to following a sudden change in engine speed. Damping is present in the form of eddy currents in the machine rotor bars and windage of the slotted disk. Tests have shown that no overshoot results from a step change in speed, and the total recovery time for a sudden change of 1 000 motor rev/min (4 000 engine rev/min) is about 100msec. Hunting does occur at low engine speeds, less than 3 000 engine rev/min where the synchronizing torque between motor and generator is also low. It is proposed to attempt viscous damping of future transducer motors if necesary, but the worst error introduced by hunting seems to be about ±2 rev/min.

Power Supplies

Two major decisions, i.e. the function of the control unit, and the use of Dekatrons, leave little choice in circuit design. The sole remaining problem is the power supply. All lines except the 6·3V a.c. must be stabilized, and the

supplies decided on were:

+390V	Dekatrons
+310V	Trigger Tubes
+240V	General Thermionic Valves
−75V	General Bias

Considerable efforts were made to simplify the power supplies. The bias supply is esential and no advantage is gained from changing its value. It was decided to series valve stabilize the 240V line for general thermionic valves, and to use this voltage as a reference level, adding to it 150V for the other line. This arrangement gives all the desired supply voltages with a minimum number of valves. A metal rectifier was chosen for the bias supply, since it has no warming-up period, and thus the bias is available before other voltages. This condition is necessary to fulfil the starting arrangements of the timing sequence, as shown previously. It was also necessary to use an indirectly heated

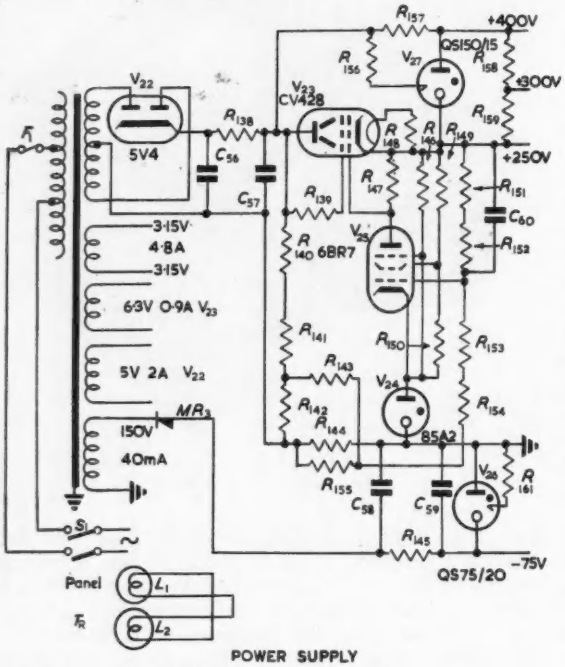


Fig. 5. The power supply unit

main rectifier valve V_{23}, and use the thermal time-constant of this valve to delay the application of d.c. to the power supply stabilizer. The d.c. output of the stabilizer will not then tend to overshoot on switching on and cause the trigger tubes to fire and upset the starting conditions.

The circuit diagram is shown in Fig. 5. For a flight power supply, three single-phase 400c/s transformers are used, with an appropriate change in filter and reservoir capacitors.

Construction

The complete equipment is housed in two cases, an indicator for remote viewing, and a case containing the power supply, transducer and controller. These latter units are assembled on a front panel which is withdrawn from a case for servicing. Each unit is detachable and interchangeable for replacement purposes, this condition applying to all units for flight or ground operation. It is possible to attach a test lead to any point in the circuit, and a soldering iron can be manœuvred inside the equipment with reasonable care.

Construction has been carried out in general to R.S.C.S. standards, material supplies permitting. The proportion of high stability and/or close tolerance components is 10 per cent, but production experience would be required to determine whether this allows a suitable safety margin. Valve interchangeability is considered satisfactory, the equipment performs reliably with all thermionic valves +20 per cent and −40 per cent of normal rating. A problem of parallax error on the indicator unit was considerably reduced by placing the engraved number panel in the same plane as the dekatron glow discharge, and designing the case so that when mounted in a panel the number plate was also in the plane of the panel.

Acknowledgments

The Author wishes to thank the Directors of the Bristol Aeroplane Company for permission to publish this article. The assistance of various colleagues, notably Messrs. R. F. Miller and D. Mills is also gratefully acknowledged.

Appendix

Notes on Test Techniques

The accuracy of the instrument tested as a frequency meter devolves on the crystal frequency and the minimum resolving time of the counter. If the crystal is accurately set up then two simple tests are sufficient to determine the performance of the equipment.

(a) Gate Timing Accuracy

It is considered necessary to check the accuracy of the timing circuit in view of the relatively slow rate of change of voltage available from trigger tubes[6]. The error to be considered is the randomness in time of the gate opening and closing events. A slight unbalance deliberately inserted in the gate valves will cause an output pulse due to change of state under no-signal conditions. This pulse is differentiated and applied to one beam of a double beam c.r.t. The other beam is excited by the crystal at 1 000c/s, the time-base being locked to it with a 1 000μsec sweep. With a reasonable sweep length, say 6in, a randomness of 10μsec in gate timing is detectable, and this order of sensitivity is sufficient for our purposes.

(b) *Counting Accuracy*

The obvious method of testing the counter, that of making it count its own frequency standard, is not very satisfactory since the timing standard is 1kc/s and the maximum signal frequency is 20kc/s. It was, therefore, decided to generate 20kc/s and 1kc/s synchronous signals. These were fed to the indicating and timing circuits respectively through phase shifting networks with a 360° coverage at 20kc/s. It was found that over a wide phase range the counter would indicate 20kc/s, that the minimum resolving time of the counter was less than 50μsec, and that the upper frequency limit was correspondingly above 20kc/s.

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Some Aspects of V.H.F. Sound Broadcasting and F.M. Broadcast Stations

(With Reference to the Performance of the BBC's Wrotham V.H.F. Station)

(Part 2)

By P. A. T. Bevan*, M.I.E.E., Sen.M.I.R.E.

F.M. Modulators

The performance of an f.m. transmitter is chiefly dependent on that of its f.m. modulator. Until recently the most generally used method of effecting frequency modulation at the transmitter was the so-called "direct" method, most variations of which use a frequency modulated *LC* oscillator whose centre frequency is then accurately stabilized in relation to the fixed frequency of a crystal controlled oscillator. The choice of system and detailed design of all f.m. modulators is considerably influenced by the practical requirement that the modulator must be capable of being set to operate at any assigned frequency within the band without making radical changes to its circuit. A good example is the modulator developed by Standard Telephones and Cables for use on Band 2 and which will be used at certain of the BBC's new stations. A block schematic of this modulator is shown in Fig. 5. It consists of a push-pull *LC* oscillator, tuneable over the range of 4·86 and 5·55Mc/s, which is frequency modulated by a push-pull reactance valve modulator driven from the audio input amplifier. The frequency modulated output of the oscillator is passed to two buffer amplifiers. One amplifier drives a standard frequency multiplier which multiplies by 18 to raise the frequency to the range 87·5 to 100Mc/s, while the other amplifier provides the output for the centre frequency stabilizing chain. For this chain the frequency of the *LC* oscillator is first brought to a standard value of 7·5Mc/s by mixing the output of the amplifier with that of a crystal oscillator operating at a frequency in the range of 12·36 to 13·05Mc/s, the selected frequency depending on the assigned frequency of the transmitter concerned. This frequency is then divided by 500 in a standard frequency divider to give an output frequency of 15kc/s. This output is passed to a balanced modulator and compared with the fixed frequency of a 15kc/s reference crystal oscillator of high stability.

The balanced modulator gives a two-phase output at any difference frequency which exists due to drift of the modulated *LC* oscillator, which operates a small, very slow speed synchronous motor mechanically coupled through reduction gears to a trimming capacitor in the anode tuned circuit of the *LC* oscillator. This capacitor is thus moved by an appropriate amount in the right sense to correct the centre frequency of the modulated *LC* oscillator. The system is capable of maintaining the centre frequency correct to within 500c/s in 100Mc/s. Failure of the automatic control circuit does not pull the *LC* oscillator off frequency and the setting-up procedure is simple.

Automatic frequency control circuits are a complication, and systems have been devised to eliminate them. One of these is the FMQ (Frequency Modulated Quartz) system[10], developed by Marconi's Wireless Telegraph Company Ltd. originally for Wrotham and which will also be used at some of the new stations. Previous attempts to modulate the frequency of a conventional crystal oscillator in a sufficiently linear manner had not been particularly successful, partly because a normal type of crystal does not

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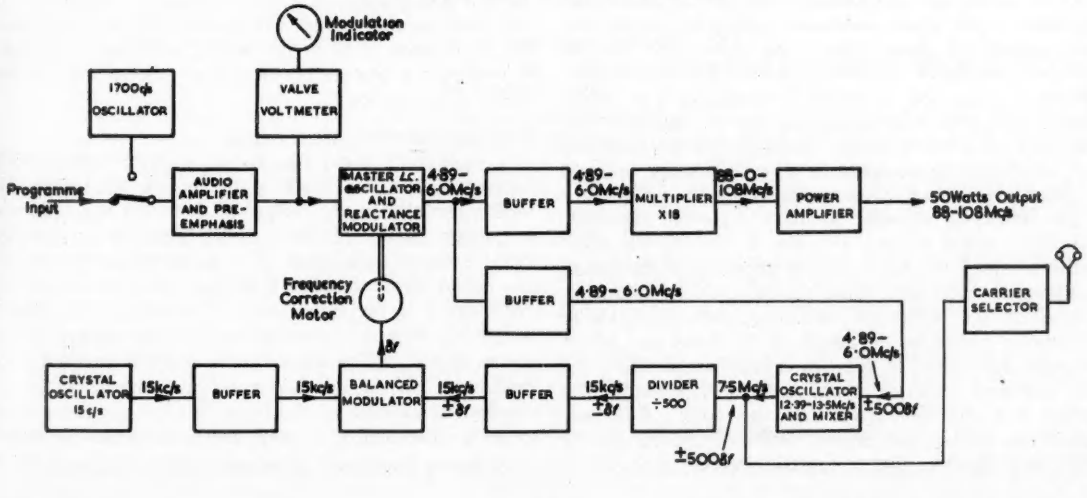
Fig. 5. Block schematic of "direct f.m." modulator



behave as a simple resonator but has a number of secondary resonances which may occur within the f.m. spectrum. In the FMQ system the introduction of a quarter-wave coupling network between the reactance valve modulator and the crystal enables linear frequency modulation to be obtained, and a type of crystal has been developed in which secondary resonances have been practically eliminated. When the equivalent network of this crystal is put into a form suitable for modulation, by transforming its series resonant impedance into a parallel resonant impedance, the resonant circuit so obtained has a high Q value and a stability far greater (about 100 times) than that of an equivalent *LC* circuit. The frequency versus susceptance characteristic of the circuit is very linear, and provided a balanced modulator of good linearity, stable mutual conductance and low noise level is used, the system is capable of providing deviations in excess of 125kc/s with a centre frequency stability of better than ± 10 parts in 10^6, together with the low noise and distortion appropriate for a Band 2 high fidelity sound broadcasting service. A block schematic of this system is given in Fig. 6.

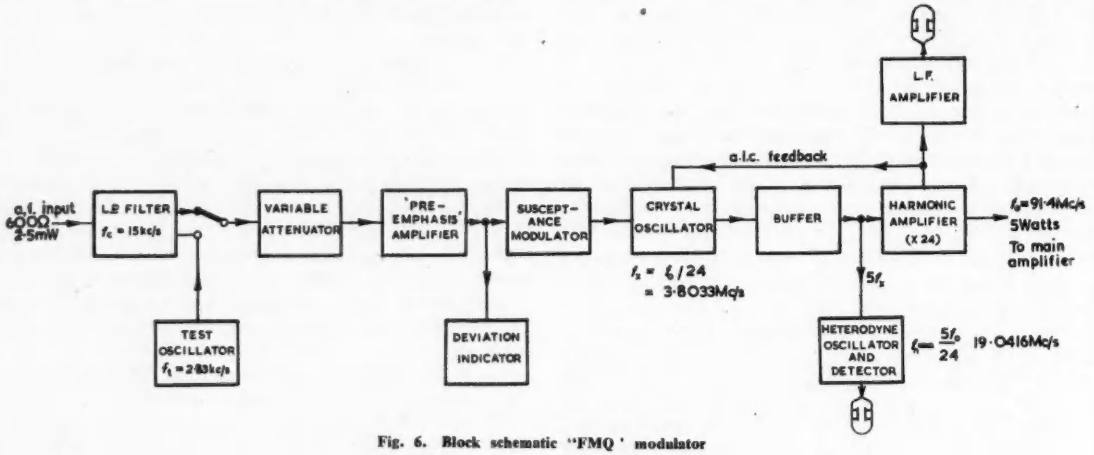


Fig. 6. Block schematic "FMQ" modulator

Another practicable system is one incorporating a method of phase modulation whereby the timing of a pulse is varied in accordance with the instantaneous amplitude of the audio frequency modulating signal, the phase modulated pulse then being converted into an equivalent frequency modulated output. This is the principle of the so-called "Serrasoid" modulator[11], in which a linear sawtooth is generated, having a repetition rate controlled by a stable crystal oscillator. In the unmodulated condition the sawtooth is clipped halfway up, and the pulse is produced at the instant when the rising front of the sawtooth changes to the horizontal. The a.f. modulating signal is then arranged to control the point on the sawtooth at which clipping occurs, and the timing of the generated pulse thus follows the instantaneous value of the a.f. signal. The maximum phase deviation of the pulse is limited by the length of the linear part of the sawtooth, which can in practice occupy about 300°.

In common with all phase modulated systems, this method has the advantage that the centre frequency stability is that of the crystal oscillator, which can be made very high, so that automatic frequency control is not needed. A practical difficulty, however, is that the crystal oscillator must have a comparatively low frequency (about 100kc/s). This is because the system uses steep-fronted waves whose rise times would otherwise be very short. The equivalent deviation at low modulating frequencies is thus rather small, and large frequency multiplication is required to obtain 75kc/s deviation at the final centre frequency. Frequency mixers are needed to give additional deviation for the lower audio frequencies and, because of the greater frequency multiplication involved, difficulty might be experienced in keeping f.m. noise sufficiently low. Most of the modulators of this type have so far been designed for narrow-band f.m. sound for u.h.f. television service, where very high fidelity and low noise are perhaps not so important.

F.M. Transmitter Performance

The Wrotham installation permitted an extension of the field trials relating to propagation, comparison of modulating systems and listening tests, and also provided the background for the development of prototype transmitting equipment together with a v.h.f. high gain aerial system and their trial under service conditions. Both the f.m. and a.m. transmitters for Wrotham were designed to provide the highest performance commercially attainable, so that the full potentialities of a v.h.f. service on either f.m. or a.m. could be determined. The performance of the original f.m. transmitter is given in Table 2 and can be regarded as reasonably typical of the future transmitters of the BBC's v.h.f. service.

F.M. Transmitter Monitoring

A high-grade radio monitoring receiver with suitable instrumentation for checking the centre frequency shift during modulation, the frequency deviation and the audio frequency quality of the radiated signal is an essential item of station equipment. It is not convenient to extract the actual centre frequency component of an f.m. signal for monitoring purposes, because this component varies in amplitude with the index of modulation and for certain values of modulation index is zero. In practice, the "mean frequency" of the signal is used, this being defined as the continuous average of the instantaneous frequency taken over a time which is long compared with the lowest modulation frequency. In an undistorted f.m. wave this is

the same as the frequency of the centre component.

The receiver is basically a limiter followed by a phase discriminator, the output current of which corresponds, in both sense and amplitude, to the instantaneous frequency deviation of the applied f.m. signal from its assigned centre frequency, the current being zero at the assigned value. The zero current point may be adjusted by reference to the frequency of a calibrating crystal oscillator of high stability. Indication of the mean frequency shift is obtained by averaging the discriminator output current over a time which is long compared with the lowest modulating frequency. Any residual direct current component which exists is a measure of the shift of the mean frequency of the signal from its proper value, and may be used to operate a centre-zero d.c. meter calibrated to read in kc/s shift.

Indication of the frequency deviation is derived from the alternating current component of the discriminator output current which has the same form as the modulating signal. Its peak value is thus proportional to the peak frequency deviation and may be used to operate a peak-reading valve-voltmeter via a linear amplifier of stable gain. The audio frequency output signal is also derived from the a.c. component of the discriminator output and is raised to a convenient level by an amplifier which incorporates the appropriate de-emphasis network. Deviation indication circuits have reasonable stability, but it is desirable that the monitor should include equipment whereby an absolute check can be made, particularly to ensure that the maximum permissible deviation is not being exceeded. The Crosby method[12] is a convenient one and involves apparatus for the separation and amplitude indication of the actual centre frequency component F of the f.m. signal radiated by the transmitter and the application of a single a.f. modulating tone of known frequency f to the transmitter modulator. The well-known series of Bessel zero amplitude levels of the centre frequency component are sequentially indicated as the amplitude of the modulating tone is progressively increased and as each zero corresponds to a known deviation ratio $B = \Delta F/f$ the absolute value of the frequency deviation is given by the product of the deviation ratio and the frequency of the modulating tone. Zero indications up to about the 6th are usually sufficient in practice. A really comprehensive monitor will also include means for measuring the noise and distortion of the f.m. signal, and such a monitor is in fact being constructed to BBC specification.

V.H.F. Aerial-Transmission Line Systems

The aerial developed by the BBC Research Laboratory, originally for Wrotham[13] and which was constructed by Marconi's Wireless Telegraph Company Ltd., is an excellent example of aerial engineering for operation at frequencies in Band 2. It is a high gain omnidirectional radiator of the slotted cylinder type giving horizontal polarization. A photograph of the aerial is given in Fig. 7. The type of construction was chosen mainly because it was a structural requirement that the aerial, when used at other stations, should also act as a support for a Band 1 television aerial[14]. Where this does not apply, and particularly at stations where the total transmitter power is lower, a simpler form of aerial may be used, such as stacked rings of dipoles or the batwing type of radiator in common use in America in 6 stack or even 12 stack form. The Wrotham type aerial[15] is rated to accept the simultaneous trans-

TABLE 2

Measured Performance of 25kW f.m. Transmitter

Frequency Range	85 to 100Mc/s
Centre Frequency Stability	Better than ± 20 parts in 10^6 for a temperature rise of 20° C and for supply voltage fluctuation of up to 6 per cent
Change of Centre Frequency with Modulation	Less than ± 10 parts in 10^6 for 100kc/s deviation
Power Output	25kW
Output Impedance	51·5Ω unbalanced
Audio Input Level	10dBm into 600Ω for 75kc/s deviation
Frequency Deviation equivalent to 100 per cent Modulation	75kc/s; maximum deviation 100kc/s
Pre-emphasis	0, 50, 75 and 100μsec pre-emphasis networks are provided and can be selected at will
A.F. Response	Within ±0·5dB relative to 400c/s over frequency range 30c/s to 8kc/s, falling to approximately 3dB down at 15kc/s and 10dB down at 20kc/s
A.F. Distortion	At 75kc/s deviation, total harmonic distortion is less than 1·5 per cent for audio frequencies from 30 to 60c/s and less than 1 per cent for audio frequencies from 60c/s to 15kc/s
F.M. Noise Level	When measured through a weighted network, the noise level is better than —70dB relative to 75kc/s deviation at 400c/s audio frequency
A.M. Noise Level	Better than —50dB relative to 100 per cent modulation at 400c/s
A.M. due to F.M. Deviation of Carrier up to 100kc/s	Does not exceed 1 per cent, plus an amount corresponding to the permitted reflexion coefficient of the aerial; total 6 per cent approximately
Power Supply Requirements	415 volts 3 phase 50c/s 90 kVA; 0·9 power factor

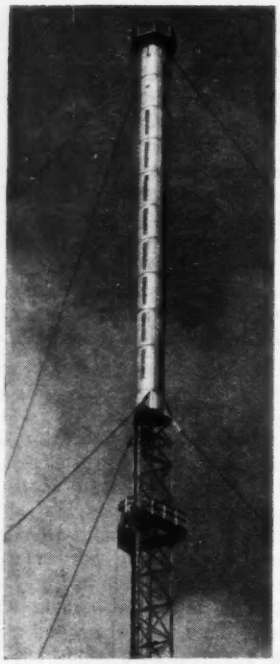


Fig. 7. The high gain v.h.f. slot aerial at Wrotham

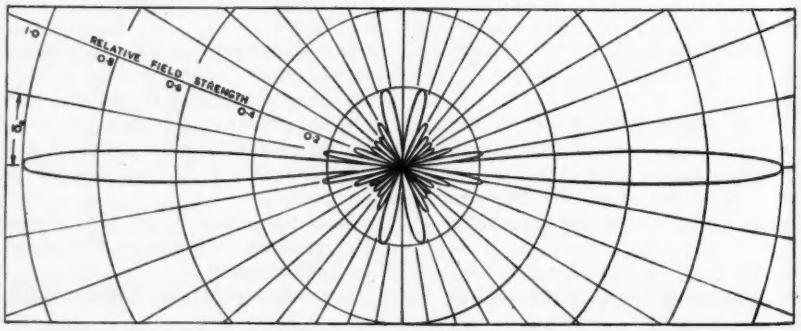
missions from up to three 25kW f.m. transmissions in the Band 87·5 to 95Mc/s. The array of 32 co-phased vertical slots is arranged in 8 stacks of 4 spaced equally round the surface of a vertical steel cylinder 6ft 6in in diameter and 110ft high, which is supported by a triangular section lattice steel mast 360ft high. Each slot is approximately 8ft long, corresponding to 0·75λ at midband, and 12in wide; the vertical spacing between slots is 10ft 6in, corresponding to λ at midband. The slots are fed at equal power and in identical phase by the successive bifurcation of the single 51·5Ω 5in coaxial main transmission line[14,16] which enables the aerial to be fairly easily converted into the "split" form if required for the system of transmitter parallel operation mentioned later in this article. The standing wave ratio of the line alone is about 1·03 over the band and the total attenuation approximately 0·65dB for the 730ft run. The overall standing wave ratio for the complete aerial system is about 1·1, but two sets of slot adjustments are necessary to maintain it over the band. One set of adjustments covers the range 87·5 to 93Mc/s, and a second set 89 to 95Mc/s. The aerial has a theoretical mean gain of about 9·5dB over a half-wave dipole, the deviation from the mean being about ±0·5dB. The gain is slightly reduced by small inequalities in the amplitude and phases of the slot-driving voltages, and when the transmission line and combining filter losses are subtracted the effective mean gain of the system is about 8dB. The calculated vertical radiation pattern is shown in Fig. 8.

At Wrotham the frequency spacing between the f.m. and a.m. transmissions was 2·4Mc/s, and to permit them to be fed into the common aerial a frequency selective "notch" type combining filter constructed from coaxial copper tube transmission line was used. This filter, which has been fully described in another article[15], gives an insertion loss between transmitters of more than 60dB at the "stop" frequencies, while for the "pass" frequencies the loss is about 0·25dB. The reflexion coefficient is less than 2 per cent. At future stations where three f.m. transmitters will feed a common aerial, this type of filter is probably not the most convenient, a more practical approach being the use of two filters of the Maxwell Bridge type[14], which are physically much more compact. These filters would be connected so that one combines the outputs of two transmitters and the other the output of the first filter with that of the third transmitter (see Fig. 9).

At Wrotham no attempt was made to "fill in" the several minima which occur in the vertical radiation pattern to avoid points of low field strength close in to the aerial. It might, however, be desirable to do this (by changing by ±90° the phase of the currents in one of the stacks of slots near the centre of the aerial) in future cases where the aerial may be located within a closely built-up area. Difficulties can also arise because of the narrowness of the main beam of the vertical radiation pattern of large aperture v.h.f. aerials with conventional symmetrical radiation patterns. The presence of the sharp zero in such patterns will result in a region of low field strength perhaps a mile or so from the transmitter and, in consequence, the relative strength of time-delayed signals reflected from objects lying in adjacent regions of much higher field strength could be large and cause a distorted combined signal at receiving aerials situated in the region of low field.

In some cases the aerial may not be required to radiate maximum field exactly along the horizontal, but arranged so that a greater proportion of the available power is directed below the optical horizon than beyond it. This can be done by "beam tilting," i.e. deflecting the axis of the main beam slightly downwards by progressively advancing the phase of the currents in the stacks of radiating elements with increasing height. This, however, is only a partial solution, and a more elegant technique is one whereby the amplitude and phase distribution of the radiator currents is based on the Fourier transform of an idealized radiation pattern[17]. The ratio of power radiated below the horizontal to that above it can then be made as high as 3:1. A possible idealized pattern is an asymmetric one having zero radiation above the horizon, constant radiation between 0° and twice the tilt angle, the radiation thereafter decreasing as cosec θ where θ is the angle of depression. Mechanical tilting of the array is sometimes used, but this tilts the beam up in one direction and down in the opposite direction. The angle of tilt required is usually very small (less than 1°) and so can be upset by high winds. Combined mechanical and electrical tilting might, however, prove useful in cases where long range is required in some directions and short in others. These techniques are perhaps not justified for Band 2 aerials with apertures less than about 8, but for v.h.f. Band 3 and u.h.f. Bands 4 and 5, where aerials having apertures of up to 16 and 24 respectively and

Fig. 8. Vertical radiation pattern of high gain v.h.f. aerial at Wrotham



hence much sharper radiation patterns are practicable, beam tilting can be of value, particularly if the aerial is very high, say 1500ft or more above the surrounding countryside.

With large aperture aerials for f.m., the design should permit a low reflexion coefficient to be realized at the operating frequencies concerned, and it is considered that 5 per cent as obtained with the Wrotham aerial should be aimed at in order to minimize the distortion which reflected time-delayed signals introduce into the radiated f.m. signal. A reflected signal, resulting from a mismatch between the aerial and its transmission line, will be partially reflected at the transmitter and radiated from the aerial delayed in time from the main f.m. signal. The resultant radiated signal then contains both amplitude

will transmit three separate programmes (Home, Light and Third) simultaneously radiated from a common aerial system. The transmitters for each transmission actually consist of a pair of identical transmitters effectively operated in parallel. Each pair of transmitters is driven from a common f.m. modulator via phasing units, and the paralleling of their outputs is by means of the "split" aerial system[14]. With this arrangement there are two completely independent transmission chains, each consisting of three transmitters, two combining filters and a single transmission line feeding one half of the aerial. The two halves of the aerial are designed so that the mutual coupling between them is very low, while the centre frequencies of each pair of transmitters is automatically maintained in phase by means of a phase monitor

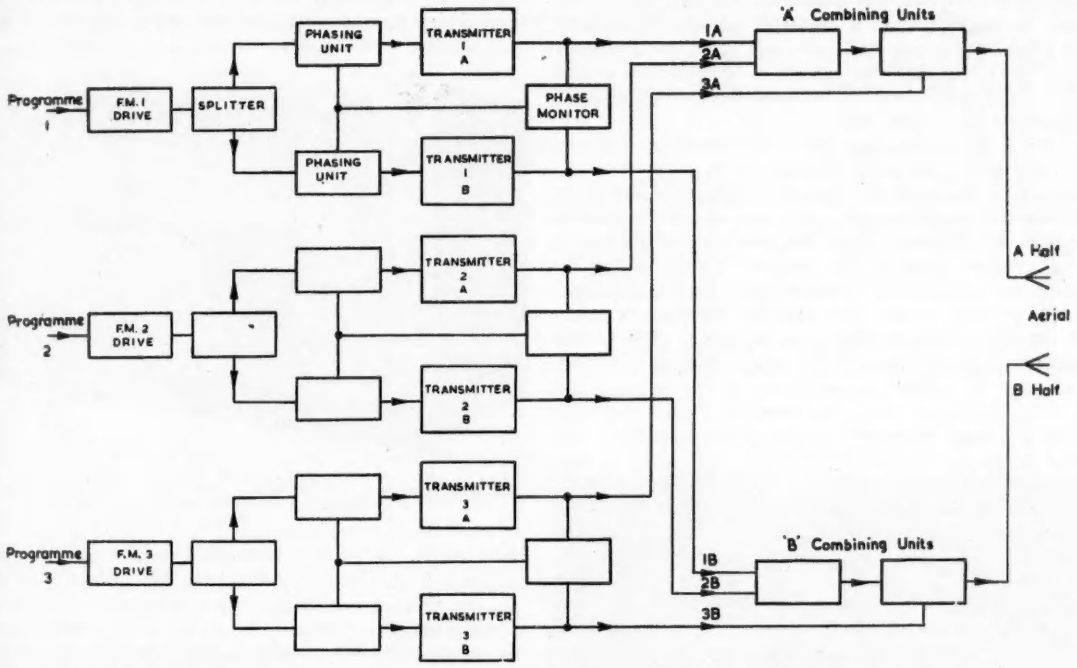


Fig. 9. Block schematic of complete f.m. transmitting station for 3 programme working and parallel operation of transmitters

modulated components and harmonic distortion terms[18, 19]. The magnitudes of these components vary cyclically between zero and a maximum with changes of phase-angle between the main and reflected signals and are, therefore, critically dependent on differences in the reflected and main signal-path lengths and on the magnitude and angle of the respective reflexion coefficients at the aerial and transmitter. The depth of modulation produced by the a.m. components cannot, however, exceed the reflexion coefficient of the aerial and in any case can be assumed to be removed by limiting in the receiver. In practice the harmonic distortion terms rarely reach their maximum amplitudes, so that the distortion introduced is small, although not necessarily negligible, in comparison with the distortion introduced by non-linearities in the phase/frequency characteristics of the transmitter and receiver circuits.

Parallel Operation of f.m. Transmitters

In the majority of cases the BBC's new f.m. stations

connected between the outputs of the pair. The advantages of this arrangement are that one transmission chain acts as a complete spare to the other, and the use of transmitter paralleling units is avoided.

A point of importance in regard to such parallel operation is that, taking any pair of transmitters, some difference both in amplitude and phase characteristics of the two transmission chains is inevitable. Small amplitude differences are not important, but any differential phase shift over the deviation frequency range of ± 75kc/s occurring between the two chains may be so. If the differential phase shift is linear, some amplitude modulation will occur in the radiated signal. If the differential phase shift is non-linear, there will also be a phase difference between the distortion components in the two chains. Investigations have shown that the latter point is not serious, and the main concern need only be with the effects of the linear differential phase shift.

By far the greatest differential phase shift is due to the transmitters themselves, because the number of tuned

circuits they incorporate is considerable (the 25kW Wrotham transmitters have 15 tuned circuits) and under practical conditions their tuning will not be identical. For example, the total phase shift through one Wrotham transmitter was found to be about $\pm 50°$ for a deviation frequency range of ± 75kc/s, while the differential phase shift occurring between the outputs of a pair of these transmitters when driven from a common f.m. modulator was about $\pm 15°$ for the same deviation and was virtually linear. The new transmitters, however, will have fewer power amplifiers in cascade and will be specifically designed for parallel operation, so that the differential phase shift between a pair is expected to be reduced to about $\pm 10°$. The combining units are expected to contribute an additional $\pm 5°$, while the differential phase shift occurring between each transmission line and half aerial should be negligible. It is therefore concluded that the total differential phase shift, over the deviation frequency of ± 75kc/s, through the system is unlikely to exceed $\pm 15°$, which corresponds to less than 2 per cent amplitude modulation due to this cause.

So far as the combining units, transmission line and half aerial are concerned it is necessary to consider not only differential phase shift, but also any fixed phase difference they may introduce between the two centre frequencies (because the phase of centre frequencies is monitored at the transmitter outputs). The combining units and transmission lines are not likely to introduce a phase difference exceeding $\pm 10°$ in the worst case, i.e. when the temperature difference between them is a maximum, while for the aerial the phase difference of the centre frequencies in the two halves is unlikely to exceed $\pm 10°$ in view of the accurate matching conditions imposed. Thus the total phase difference between the centre frequencies in the aerial should not exceed 20°, which is too small to have any significant effect on the polar diagram. Fig. 9 shows a block schematic of a complete f.m. transmitting station arrangement based on the scheme of operation discussed above.

Unattended Operation of f.m. Transmitters

The use of pairs of transmitters effectively operated in parallel for each transmission ensures a high degree of immunity from breakdown, which is all the more essential in the case of the BBC's new f.m. stations because it is intended that the transmitters shall normally be arranged for remote-controlled unattended operation. The unattended operation of transmitters introduces several new problems in transmitter engineering. In particular it means that the conventional sequential procedures involved in switching a transmitter on and off and the system of fault protection must be fully automatic. It also implies the use of a comprehensive overall programme monitoring system, automatic in action, whose task is to compare the incoming programme signal with the f.m. output signal, and operate appropriate alarms and trips if any serious discrepancy occurs. Space precludes a description of the programme monitoring system, but one of the forms of transmitter automatic control which shows good promise is mentioned below. The principle of this system is the provision of a special moving-coil automatic voltage regulator which controls the voltage of the input a.c. power supply to the complete transmitter equipment. On switching on the transmitter, the regulator energizes all supplies to the power amplifiers and auxiliaries gradually and simultaneously, the supply voltage rising from approximately zero up to the normal working value in approximately one minute; it then automatically stabilizes the voltage at the correct value. In the event of an overload fault or incorrect operation in any of the transmitter circuits, the appropriate protective relay operates a fast release mechanism which causes the regulator to reduce the input supply voltage to approximately zero in about three seconds. An automatic reclosing device then comes into operation which restores the voltage to normal. If the fault is still present, the regulator again releases and remains at its zero voltage position. Normal switching off operates the fast release mechanism without bringing in the reclosing device. This system has the merit of simplicity because in addition to removing the need for sequential interlocking relays, contactors and motor starters, all a.c.

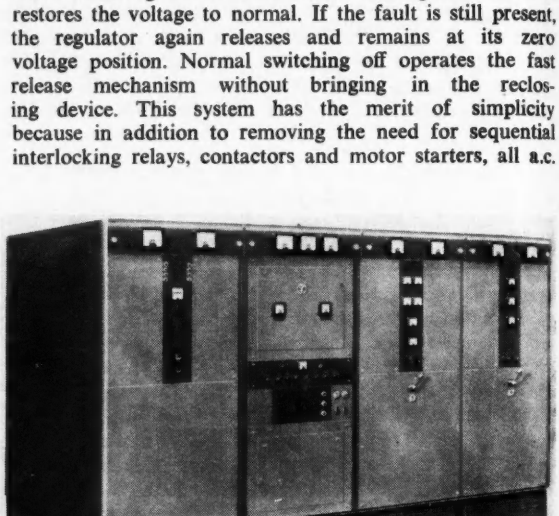


Fig. 10. A modern v.h.f. 10kW f.m. Broadcast transmitter designed for remote-controlled unattended parallel operation

sub-circuit distribution contactors and fuses are also eliminated since these circuits may be connected directly to the control regulator output terminals via current transformers, in the secondaries of which are standard overload protective relays which operate the release mechanism of the regulator. A single on-off switch controls the whole transmitter. A photograph of a modern 10kW f.m. transmitter designed on this basis is shown in Fig. 10.

Conclusions

The BBC has already received government approval for the construction of the first 10 high power f.m. stations. It is hoped that most of these will be in operation by the end of 1956 but, in the authors' opinion, the fulfilment of this programme will inevitably be determined by the ability of the transmission side of the radio industry to deal with it, bearing in mind the demands also being made on this side of the industry by the introduction of independent television on Band 3. Much of the equipment required for the Band 2 sound and Band 3 television services is similar, namely, v.h.f. transmitters of 10 to 20kW output, high gain aerial systems, low loss transmission lines and high masts.

Very high frequency sound broadcasting, in this country, is nevertheless about to emerge with great vigour from the experimental stage and take practical shape. Its adoption

should place sound broadcasting on a far better footing than it is today because it provides a means of escape from the worsening congestion in the low and medium frequency bands and at the same time confers the benefits of a much higher quality service. The v.h.f. scheme envisaged by the BBC is being planned to this end, and priority will be given to the areas which are in greatest need of an improved service. Eventually a three programme v.h.f. service to approximately 98 per cent of the population should be achieved. The decision that the system of modulation should be f.m. is based on the fullest possible appraisal by the radio industry in general of all the relevant theoretical, practical and economic considerations. The high standard of technology required for the development of f.m. transmitting plant and high grade receivers and adaptors for existing m.f. receivers is available in this country, and much of the plant for the new stations is already in works production. V.H.F broadcasting, coupled with f.m., indeed seems to be "Sound Radio's Second Chance."

Acknowledgments

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A Very High Speed Camera

A SEQUENTIAL image convertor (type SP.2), manufactured by Winston Electronics Ltd., has recently been flown to America for use at the Aberdeen Proving Grounds, one of America's major weapon-testing centres. The camera formed part of the freight on the first flight of the new transatlantic freight service inaugurated by Airwork Ltd.

The camera employs a Mullard image convertor tube (type ME1201AA), which is basically a cathode-ray tube fitted with a photo-cathode instead of a heated filament.

An optical image is focused by an optical system on to the photo-cathode. The light distribution in the optical image is converted into an exactly similar distribution of emitted electrons. The electrons are focused by a magnetic field and accelerated by the action of the grid and anode. On striking the luminescent screen the energy of the electron is converted into light and an exact reproduction of the original is obtained.

In order to use the image convertor as a high speed cine-camera the tube is normally cut-off by the action of the grid and it may be turned "on" for a length of time as short as 0·01μsec by applying suitable pulses to the grid.

Further the beam of electrons may be deflected by the action of an external magnetic field. A small square picture can thus be deflected into several distinct positions while the grid is at the same time pulsed switching the i.c.t. on.

The SP.2 image convertor does this giving two rows of three pictures each 20×20mm size. Seven shutter speeds are available; the rate of scanning is locked to the shutter action in such a manner that the interval between the shutter pulses is always five times the length of the shutter pulse.

The following table gives the available shutter speeds with the respective frame rate and maximum repetition frequency (of a complete sequence).

SHUTTER SPEED (μsec.)	FRAME RATE (c/s)	REPETITION FREQUENCY (c/s)
0·1	2×106	500
0·2	1×106	500
0·5	4×105	500
1	2×105	500
2	1×105	250
5	4×104	100
10	2×104	50

The action of a complete cycle is initiated by a trigger pulse which must be roughly +100V high. The trigger action can be delayed by 0·1 to 1μsec or longer if required.

The optical image is focused on the photo-cathode by means of a Gregorian telescope system.

The resulting picture on the luminescent screen can be photographed on a 4in×5in film.

Due to the very small amount of light being allowed to get through to the photographic plate the objects must either be intensely self-luminous such as spark discharges, explosions, etc., or they must be illuminated by a highly luminous source such as gas-filled flash tubes e.g. LSD.2. These light sources must of course be synchronized with the image convertor equipment.

At speeds longer than 1μsec the resolution of the complete system is approx 200 lines/cm and at higher speeds 60 lines/cm (these figures do not take into account the grain of the film). The maximum shake of the 2cm square picture is 0·03cm.

The complete equipment consists of two steel racks 6ft high on a 2×2ft base.

Development of light in LSD2 flash tube. 0·1μsec. exposures at 0·5μsec intervals

Some Recent Developments in

American Electronic Musical Instruments

By Alan Douglas

Since the inception of commercial musical instruments, the basic forms and types of generating systems have remained unaltered. No new method of tone generation has appeared. Development has therefore taken place to exploit already existing resources still further, with the principal objects of providing better tonal synthesis and increased flexibility of control. This article reviews the latest American practice in these matters.

WE will take the Hammond organ first, as it is better known than any other instrument and has strongly marked characteristics of its own. It is not proposed to describe the complete instrument[1] or its theory[2] again, but to introduce the latest modifications.

The weakest element of the organ has always been the pedal section. Now, a complete series of harmonics is made available by the multiple pedal key switches, Fig. 1. The tone sources for these are derived from the main manual generators. Thus there is a wide range of synthetic sound to balance corresponding manual combinations.

A more interesting addition on the RT models is the

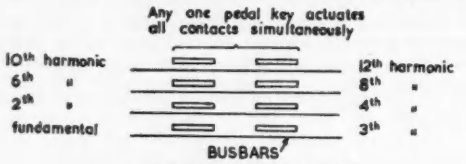


Fig. 1. Hammond pedal key contacts

solo pedal generator. This not only provides tones down to 32ft pitch, but enables a pedal solo to be taken on the right foot while the normal bass is maintained by the left foot—a situation capable of great exploitation. Fig. 2 is the complete circuit of this apparatus, which in essence is a continuously-tuned *LC* oscillator. Thus only one note at a time can be played. The normal use of the pedals is not invalidated, since the switching arrangements ensure that only the upper note will speak on the solo circuit, which can be disconnected at will. The interesting feature is that tone generation is at 1ft pitch, which is then divided down to 2, 4, 8, 16 and 32ft pitch. An enormous range of tonal combinations is thus available to the player, some of which can be preset on toe pistons. The rate of attack is not adjustable, but a good general compromise has been effected. This unit has its own power supply and expression pedal. No special loudspeakers have been evolved for this circuit, but the level of the 32ft tones is low and so they are unsuitable for use alone.

On certain models a main generator having complex tone wheels can be obtained. These supply odd harmonics and their judicious use does much to offset the lack of certain intervals which, due to tempered scale interference, are not suitable for the additive method of tonal synthesis, and which were not available on previous models.

The reverberation device has been improved in design and response, and is shown diagrammatically in Fig. 3. It will be recalled[1] that part of the final signal is passed directly to the main amplifier and part through this unit to the same amplifier. There is thus a delay which introduces very complex and insoluble phase relationships but, since the frequencies comprising the signal are subjected to repeated reflexions through the springs, results in an apparent sustaining of the general sound spectrum. The initial delay is about 66msec, the second spring adds another 133msec, and so on; but there are innumerable secondary reflexions and these are in part adjustable by controlling the quantity of oil in the tubes, effectively

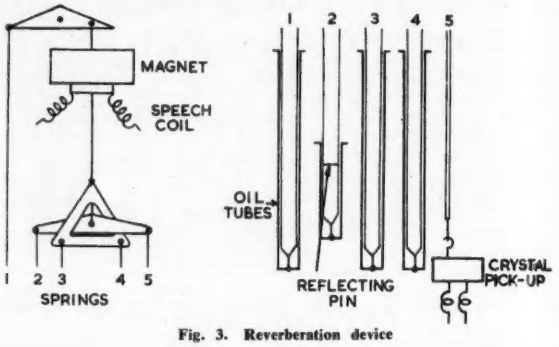


Fig. 3. Reverberation device

lengthening or shortening the springs, and so varying the propagation time.

In effect, when well set up, the reverberation device gives continuously overlapping phase shifts having five major time/frequency components and a very large number of smaller phase shifts. The effect is theoretically good but æsthetically poor in small rooms. True reverberation is a function of all the active areas of the room, whereas in this application it is confined to the radiating surface of the loudspeaker cones.

A number of minor changes have been made in the vibrato line scanner[1], expression controls and the generator filter circuits, but these do not substantially alter the general tonal structure of the sole example of an additive music generator having individual tone sources for each note. Incidentally, there are 14 different models of the Hammond organ in current production, besides the Spinet[3], Chord[4] and Solovox[5] instruments.

There has been a marked tendency in the United States to neglect the electro-mechanical tone generator and to concentrate on the valve instrument. In view of the ready availability of cheap valves and the profusion of well-engineered communication elements, this is not surprising. At the same time, it is by no means easy to make a successful rotating generator, and the manufacturing and assembly costs are high. A new organ to be introduced by the Baldwin company uses rotating photo-electric

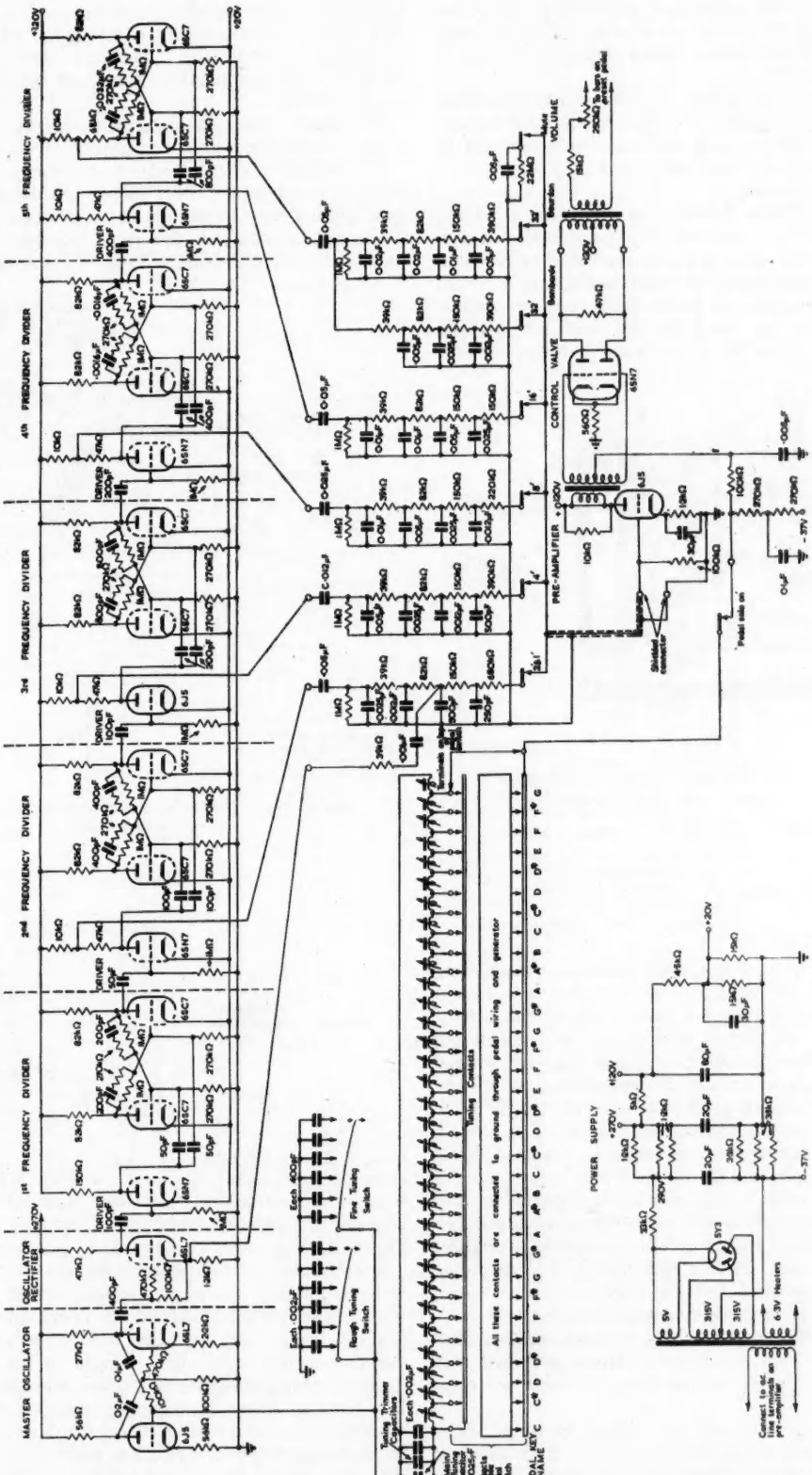


Fig. 2. Hammond pedal solo generator and control circuits

generators and a few models are undergoing field tests; as it is not yet on the market, no details can be disclosed. This also has a reverberation system relying on springs, as an optional fitment.

The only remaining example of other electro-mechanical instruments is the vibrating reed organ made by Wurlitzer. It is largely due to their long experience with pipe organs and the suitability of their plant that they continue to produce this instrument.

Earlier models[6] were based on a development of the Hoschke patents[7], and used electrically-operated valves as in a pipe organ to admit wind to the reeds as required. To meet the competition of instruments with a much quicker rate of speech, the pallet valves have been abandoned in the current series and the reeds vibrate continuously. The signal is then keyed through suitable transient filters.

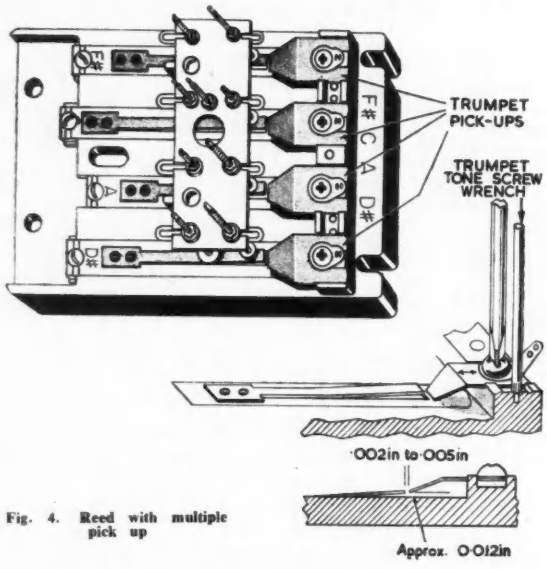


Fig. 4. Reed with multiple pick up

This time we will select a small model as exemplifying the resources of the method to the full. The type 44 is a domestic instrument using the extension principle. Briefly, this means that all pitches of any one tone colour are extracted from a continuous row of sound sources instead of having overlapping rows of different pitches as in many pipe organs. Thus a 4ft pitch is taken from the 8ft pitch reeds but one octave higher, and so on. The loss in combination is not so great as might be expected, being roughly 8 to 10 per cent. Most small pipe organs use this principle now, which results in marked economy in cost and space. The method is fully explained in the literature[8]. One thing extension cannot give in a physical instrument is a change of tone quality, and this is an outstanding advantage of electrical systems; from the same sound source, various contrasting effects are possible.

The type 44 Wurlitzer has only 73 reeds for the entire instrument, yet from these, flutes, strings and reed tone from 8ft to 1⅓ft pitch and covering 61 notes are compounded.

Fig. 4 shows a reed with its multiple pick-ups. Since such "free" reeds are in fact bars clamped at one end, many overtones are developed along the blade. By careful disposition of the capacitive pick-ups, and by changes in their surface areas, different frequency bands can be emphasized. Further, by polarizing these pick-ups at different levels, the relative strength of the tones may be greatly varied.

The many pick-ups, with their transient suppression circuits (which are printed on phenolic cards), are collected at the multiple contacts under each playing key (Fig. 5). Here, by the busbar system shown, any number of these tone sources may be combined to produce a composite signal. So comparatively few reeds require only a modest supply of wind to maintain them in vibration, as distinct

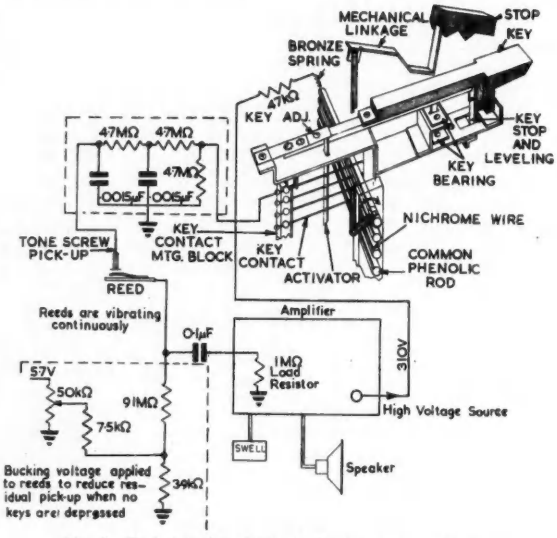


Fig. 5. Typical keying circuit to the tone screw pick-ups. M-44 Wurlitzer organ.

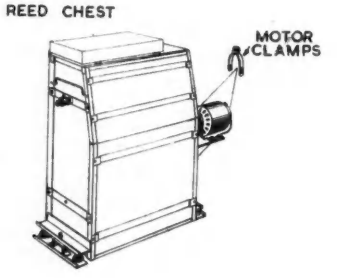


Fig. 6. Arrangement of reed chest and fan

from starting them; a motor of 1/12 h.p. drives an impeller submerged in the reed chest (Fig. 6). This contains all the reeds mounted on bakelite blocks as in Fig. 4. Each pick-up is adjustable by a special spanner.

The busbars are rotated to make contact with the key wires by the stop tablets, by a simple mechanical coupling. No "tone-forming" is carried out in the amplifier, which is divided into treble and bass input channels. The main purpose of this is to apply vibrato to the treble only. This is accomplished by the rather elaborate circuit of Fig. 7, which shows the complete amplifier. Note that the vibrato frequency is removed by the filter $R_{39\ 40}C_{17\ 19}$, so that each 7th or 8th signal is shifted in phase during the excursion of the vibrato oscillation. This produces a

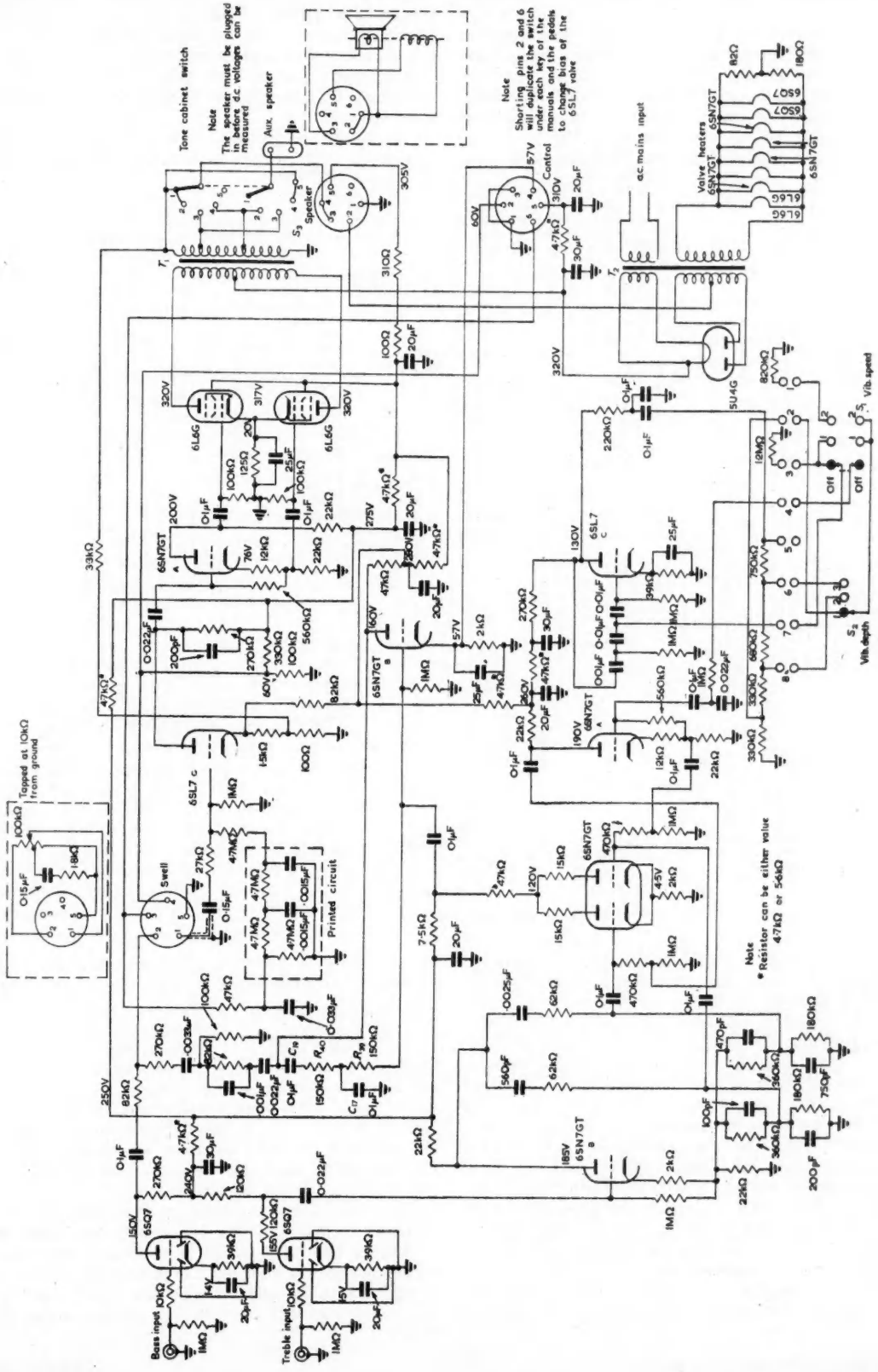


Fig. 7. Wurlitzer amplifier and vibrato circuit

type of undulation which is particularly pleasing to the ear.

The mechanical excellence of the construction is typical of the workmanship for which Wurlitzer pipe organs have always been noted.

Perhaps the Conn organ is more generally interesting, since it depends on valve oscillators. In the original instrument[9], 132 valves were employed. The generating circuits[2] are substantially unaltered, but the writer was always of the opinion that the tonal possibilities were not fully exploited. In the new instruments, a much better synthesis is achieved and the circuits are partly shown in Fig. 8. As has been explained[10], it is impossible to add individual synthesized tones if these are derived from one waveform only, or if the filters or tone-forming elements are substantially common to one waveform. The Conn oscillators provide a sinusoidal output as well as a separate pulse. It is from this latter that most of the complex tones are formed. Very wisely, no attempt is made to form tones outside the capabilities of these waveforms; for instance, a sawtooth wave would permit many more tones than are possible from a quite triangular pulse.

The use of isolating valves is a sound way to avoid intermodulation, and as there are separate groups of oscillators for each keyboard and the pedals, a good chorus effect is possible. This company also favours the use of multiple contacts under the keys, but in this case they act as couplers to make available the different pitches. The valuable "unison off" is thus obtainable. It will be noticed that the tones formed by Fig. 8 are appropriate to the small church organ, and one might feel that a more liquid flute or tibia would be an asset for the home. It is quite easily formed from the waveforms available.

Apart from the Baldwin organs[11], the most interesting application of frequency division is to be found in the Minshall range of instruments. Phase shift oscillators feed a chain of cascaded dividers with the configuration of Fig. 9, which work as follows.

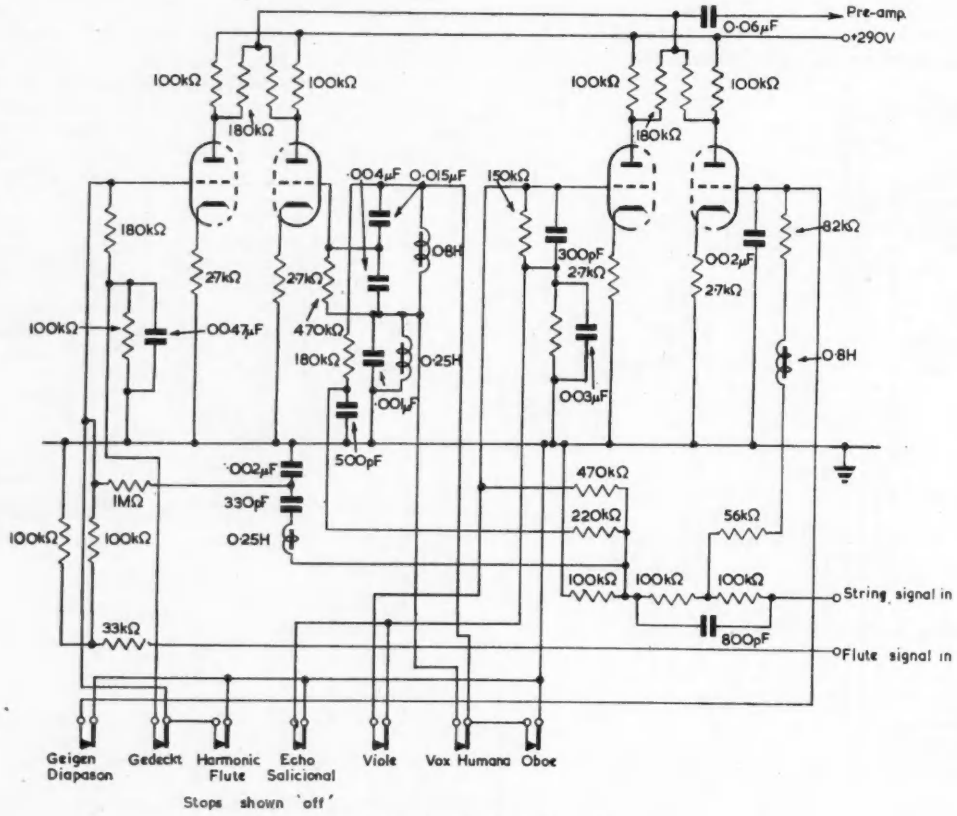


Fig. 8. Conn tone circuit, swell manual

The first peak of the input signal voltage reduces the anode voltage as the valve conducts, and this is fed back to the control grid delayed in time by the constants of the feedback resistor and grid capacitor. So when the second peak of the input signal arrives, the grid potential is more negative (due to the fed-back signal) than when the first peak arrived. The input amplitude is not now high enough to overcome this extra bias and the second peak therefore causes no conduction.

The anode capacitor is thus not discharged, but in fact continues to charge up. By the time the third input peak arrives, the bias has returned to its original value and the anode capacitor is discharged. The resulting voltage drop is fed back to the grid, arresting the fourth input peak. The valve therefore conducts on alternate input peaks

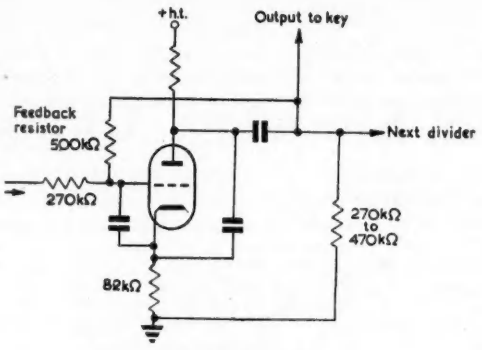


Fig. 9. Minshall frequency divider

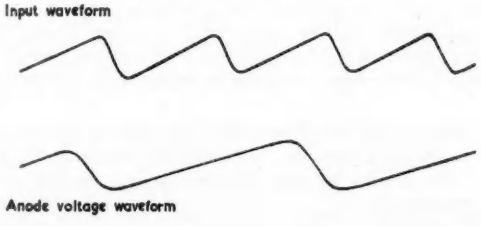
only, and so divides the frequency by two. The circuit is to some extent frequency dependent, but will function over about half an octave with the same component values. The waveforms are shown in Fig. 10.

An attempt has been made to obtain the synthesis by simpler or more effective circuits than in the past; it might be added that the patent situation has a lot to do with this. In the Minshall system the tone switches or "stops" are shunt connected. Fig. 11 shows a typical circuit for one keyboard. The valve is connected as an amplifier with a reactive phase shift network between anode and grid. The impedance between input and earth will then vary markedly with frequency according to the proportions of the circuit constants.

Over some band of frequencies the phase of the feed-back circuit reinforces the input voltage, and a peak in the response is produced. At low frequencies the phase of the fed-back signal opposes the grid signal, producing a low impedance from here to earth. The response then falls off towards the bass end until the reactance of the input coupling capacitor becomes significant, when it will begin to rise again. The circuit acts like a resonant filter, peaking at one frequency and having attenuation at another. Control over these pass- and stop-bands is effected by the auxiliary networks marked with the tone-colours. The response of the networks is shown in Fig. 12. It will be noticed that the "diapason" uses the waveform as generated without modification. Such a music generator requires octave and sub-octave couplers to exploit the system fully.

In general, it may be said that no new oscillator circuits have appeared for musical instruments and no new loud-speakers have been developed, although the 27in Altec-Lansing is used by the Allen Organ Company for large installations. The introduction of two overlapping key-boards as in the Hammond "Spinet" is becoming common, and for the smaller organs a fixed arrangement of 13 or 18 pedal keys is more or less universal, to give an elementary bass. The better-class instruments seek to develop the potential tonal content more accurately regardless of cost or complication, while the less expensive ones have tried to find still simpler and cheaper circuit artifices.

Fig. 10. Divider waveforms



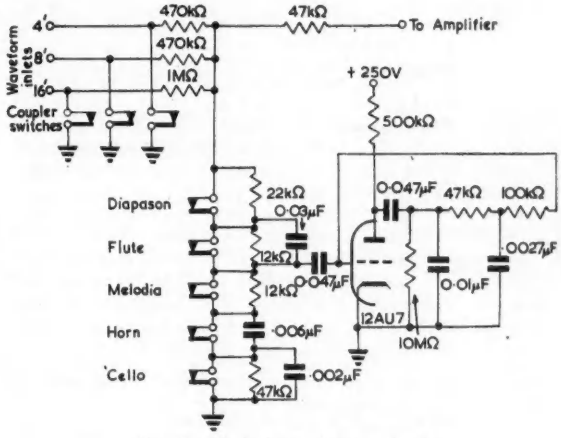


Fig. 11. Minshall tone forming circuits

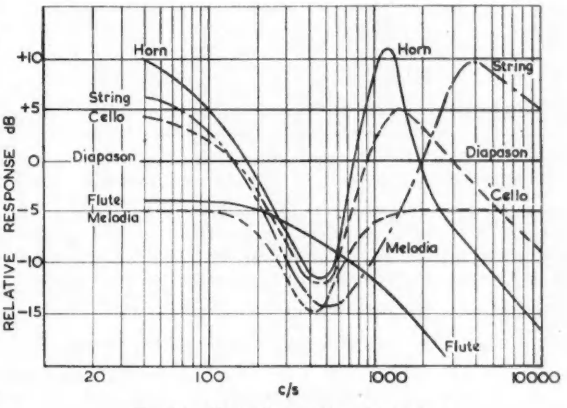


Fig. 12. Effect of tone filters on response

The impact of the electrical music generator on the domestic market has been remarkable. At one time, of course, the reed organ was to be found in nearly every home; hence the term *American* organ. Now its modern counterpart is well on the way to recapture the market. The magnitude of this can be gauged from the sales of one company alone in 1953—$10 000 000.

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A High-Speed Waveform-Sampling Circuit

By G. D. Bergman*, B.Sc., and D. M. MacKay*, B.Sc., Ph.D.

This article describes a new method of sampling a rapidly changing voltage waveform at a high sampling frequency. The circuit employs negative feedback in such a way that sampling pulses of specially small duration and amplitude can be used. Two practical forms of circuit are described which give a stepped output, and a theoretical discussion of the important design parameters is given.

PULSED sampling circuits can be designed to give outputs of two basic types, either a series of pulses modulated in height or duration to represent the amplitude of the sampled signal, or a stepwise modulated voltage which remains steady at each sampled value during the interval until the arrival of the next sampling pulse (Fig. 1).

This article is concerned with circuits of the second type, required to give a stepped output.

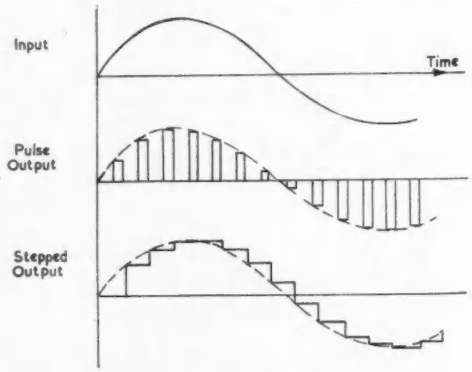

Fig. 1. Two types of output for pulsed sampling circuits

A conventional sampling circuit of this type is shown in essentials in Fig. 2. Short positive and negative sampling pulses P and Q respectively render diodes D_{1-4} conducting in order to allow the storage capacitor C to charge or discharge to the potential of the cathode of V_1, which follows the input.

When P and Q return to suitable resting levels C is left isolated and the output from the cathode of V_2 remains steady in the absence of leakage.

Circuits of this type suffer from two disadvantages that limit their range of application:

(a) The sampling pulses P and Q (of opposite polarity) must have amplitudes greater than the peak-to-peak input voltage range and must return to resting-levels below minimum and above maximum input respectively (see Fig. 3). At high sampling rates, where very short and rapidly-rising pulses must be used, this large voltage-swing demands a pulse generator of undesirably high power.

(b) The heater-cathode leakage resistance (R_c) of diode D_3 sets an upper limit of CR_c to the time-constant of the storage circuit unless the heater can be tied to the cathode and isolated. The output tends in consequence to "droop" unless the pulse-to-pulse interval is short compared with CR_c. To offset this by increasing the value of C would increase proportionately the minimum time required to charge or discharge the capacitor, unless again a higher-powered sampling pulse were used.

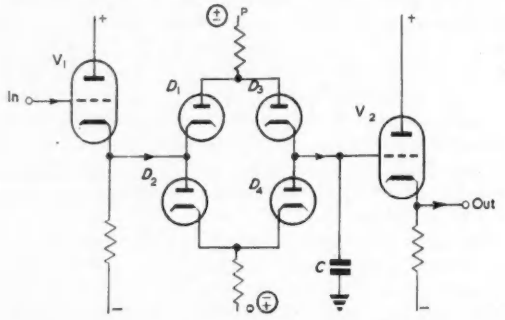

Fig. 2. A conventional pulsed sampling circuit to give a stepped output

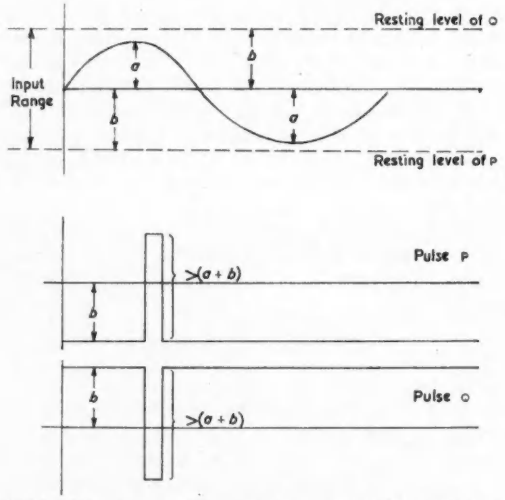

Fig. 3. Voltages required to operate conventional circuit of Fig. 2

In an effort to reduce these demands to a minimum, a

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sampling circuit has been devised which requires much smaller switching-pulse amplitudes and can tolerate heater-cathode leakages greater by several orders of magnitude[1].

Basic Principles

The basic principle of this circuit is illustrated in Fig. 4.

A cathode-follower V_1 receives the input V_{in} via a resistor R_1, and feedback from the output V_{out} via resistor R_2. A diode-switch circuit (represented by S) leads from the cathode-follower to the input of a sign-reversing amplifier A of gain $-\alpha$, between whose input and output terminals the storage capacitor C is connected.

The two essential features are:

(a) Subtraction of the output from the input to the diode-switch so as to bring the input level at Y more or less to zero when the diode-switch S is closed. This greatly reduces the pulse-voltages needed to operate S.

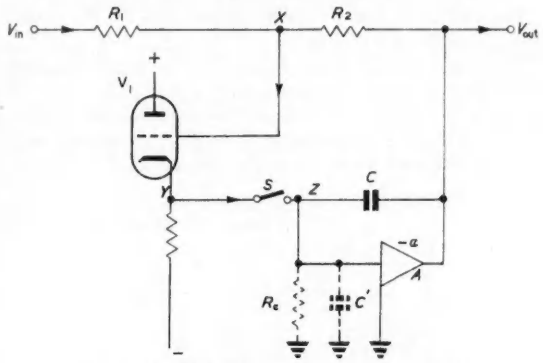


Fig. 4. Simplified diagram of new sampling circuit

(b) Connexion of the capacitor C between input and output of amplifier A, so as to amplify the effective time-constant of the input circuit without increasing the charging current required.

The basic operation of the circuit may be followed in two stages.

(1) If S is closed, the circuit functions as in a conventional seesaw circuit so as to bring the output voltage to a value approximately $-(R_2/R_1)$ times the instantaneous input voltage. During this phase the capacitor C is charged to a voltage approximately equal to the output voltage, the necessary current flowing via S.

(2) If S is now opened, the output remains clamped at the sample value by virtue of the negative feedback exerted through the charged capacitor C. Feedback through R_2 ceases and the grid and cathode of V_1 are free to follow changes in the input attenuated in the ratio $R_2/(R_1 + R_2)$.

If the leakage resistance from the diode switch S to earth is R_e, the effective leakage time-constant, owing to the well-known Miller effect, is now $(\alpha + 1)\,CR_e$, which can in theory be made as large as desired by making α sufficiently large.

The output impedance while S is closed will be approximately the reciprocal of the loop transconductance,

$$Z_{out} = (1 + R_2/R_1)/g_m'$$

where g_m' is the transconductance between the point X and the output of A.

With S open, the output impedance is approximately:

$$Z_{out} = 1/g_m$$

Where g_m is the transconductance from the point Z to the output of A. If leakage through R_e is not neglected, this expression must be divided by the attenuation operator for the potential divider (C, R_e), so that in operational notation:

$$Z_{out} = (1 + 1/R_eCp)/g_m$$

More exact expressions for these quantities are derived in Appendix 1.

The input impedance changes from approximately R_1 when S is closed, to $(R_1 + R_2)$ in series with the steady output voltage when S is open. Except when the amplitudes of successive samples are the same, there will be an abrupt change in the input current to R_1 when S

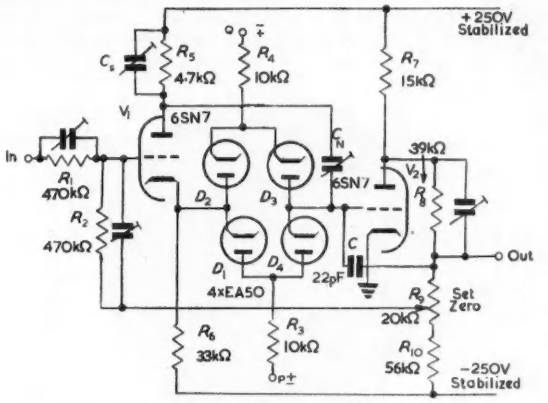


Fig. 5. A practical sampling circuit using the minimum number of valves

closes. Since, however, the impedance of R_1 and R_2 can normally be high, the discontinuity in load current will seldom have serious enough effects on the preceding stage to justify the use of an isolating cathode-follower ahead of R_1.

Practical Circuit

A practical circuit using the minimum number of valves is shown in Fig. 5.

The diode switch D_{1-4} is supplied with pulses of the order of 20V in amplitude and 0·5μsec in duration. The grid of V_2 need never change in potential by more than 5V, so that it is sufficient to prevent leakages if P and Q are biased to some 5V below and above the mean grid voltage respectively.

While P and Q are "resting" the cathode voltage of V_1 may change, owing to a change in the input voltage, sufficiently to render D_1 or D_2 conducting.

Thus the value of resistors R_3 and R_4 must be high enough to avoid overloading the cathode-follower V_1 under the worst conditions. At the same time R_3 and R_4 must be small enough to allow an adequate charging current to flow to or from C in a fraction of the duration of the sampling pulse.

If the maximum expected voltage change across C in one sampling operation is ΔV, the mean current required in time Δt is $C\Delta V/\Delta t$. The pulse height above (or below) grid potential must then exceed $C\Delta V/\Delta t$ times R_3 or R_4.

For $C = 20$pF, $\Delta V = 25$V, $\Delta t = 0{\cdot}5\mu$sec and $R_3 = R_4 = 10$kΩ this gives a minimum pulse-height of 10V above or below grid potential.

With the h.t. voltages shown, the input range of the circuit of Fig. 5 was limited (by the output stage) to some ± 20V, but this does not, of course, represent a limitation of the sampling circuit. With smaller signals, or signals changing in smaller steps, the pulse voltage could be still further reduced.

Since the signal may be conducted by D_1 or D_2, while P and Q are resting, an appreciable signal may be transferred to the grid of V_2 via the self-capacitance of D_3 or D_4, which may not be negligible compared with the storage capacitor C.

To offset this effect the neutralizing capacitor C_n is connected to the grid of V_1, and supplied with a signal in antiphase with the cathode voltage. The shunt capacitor C_s helps to equalize the effects of stray capacitance at the

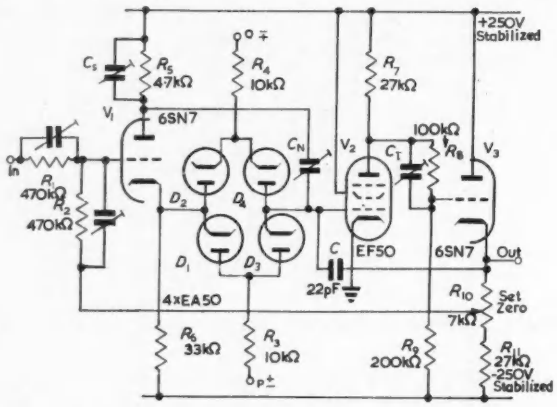


Fig. 6. A practical circuit with lower output impedance

cathode of V_1, and the arrangement results in an appreciable reduction of the stray signals in the output. It has been found especially valuable when the waveform sampled was a sawtooth, used in decoding position-modulated pulses.

If $(R_1 + R_2)$ is of comparable order of magnitude with the output impedance an appreciable fraction of the input will be transferred to the output without change of sign during the resting periods. This fraction can, in particular cases, be made large enough to compensate for the strays across the diode switch mentioned in the previous paragraph. In some cases compensation may be excessive. It can then be neutralized by augmenting the stray capacitance across the diode switch. Since this adds to the capacitance between the grid of V_2 and earth it will have the undesirable effect of increasing the output impedance during the resting periods. (See Appendix 1.)

The input and feedback resistors R_1 and R_2 are shunted by small trimming capacitors of the order of 20pF to maintain a good high frequency response. The feedback through R_2 must, of course, operate within a fraction of the duration of the sampling pulses.

The zero-level of the output is preset by adjusting the potential of the point from which feedback is taken to R_2.

The simple circuit of Fig. 5, designed for maximum economy, has a measured output impedance of 7kΩ and a leakage time-constant of the order of 0·5msec with a 22pF capacitor C and a leakage resistance R_e of 2MΩ.

It can obviously be much improved by replacing the triode V_2 by a pentode with a cathode-follower output stage.

A satisfactory circuit incorporating these refinements is shown in Fig. 6.

It differs from Fig. 5, mainly in the range of output voltages it can handle, and in its output impedance. V_1 fulfils the same function as V_1 in Fig. 5, while V_2 and V_3 form the amplifier replacing V_2 in Fig. 5. The d.c. coupling from V_2 to V_3 via R_8 and R_9 is frequency-compensated by the trimming capacitor C_T.

This circuit has a measured output impedance of about 17Ω, and was capable of handling input signals between ± 50V, with the h.t. voltages shown.

Appendix

The circuit of Fig. 4 can be represented by the equivalent circuit shown in Fig. 7.

The cathode-follower is replaced by a voltage generator which has an output resistance R' and a gain $+\beta$. The amplifier A is replaced by a current generator of transconductance G_m and output resistance R''. C' represents the stray capacitance from the point Z to earth.

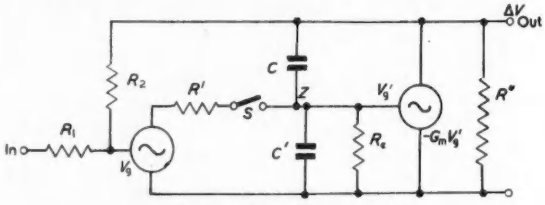


Fig. 7. Equivalent circuit of Fig. 4

The output impedance can be calculated for the two cases:

(1) S closed, (2) S open.

Case (1) S closed

Suppose the input is held at a constant potential and a voltage ΔV is applied to the output terminal. The input voltage to the cathode-follower will change by an amount:

$$\Delta V_g = \frac{\Delta V R_1}{R_1 + R_2}$$

Since R' is very small compared with R_e, and small compared with the reactance of C and C' at the frequencies for which this equivalent circuit is applicable, the change in voltage at the grid of the amplifier A can be written:

$$\Delta V_g' = \frac{R_1}{(R_1 + R_2)} \Delta V \beta$$

The change ΔV thus produces a change in current Δi at the output.

If the current in R'' is neglected for the moment:

$$\Delta i = G_m \frac{R_1}{(R_1 + R_2)} \beta \Delta V$$

This corresponds to an output resistance:

$$\Delta V / \Delta i = (1 + R_2/R_1)\ 1/\beta G_m$$

This is in parallel with R'' so the output resistance will be:

$$Z_{out} = \frac{R''(1 + R_2/R_1)\ 1/\beta G_m}{R'' + (1 + R_2/R_1)\ 1/\beta G_m}$$

CASE (2) *S* OPEN

Again ΔV is applied to the output terminal. The voltage change at Z (in Transform notation) will be given by:

$$\overline{\Delta V}_g' = \frac{\overline{\Delta V}\,\dfrac{R_e}{1 + pR_eC'}}{1/pC + \dfrac{R_e}{1 + pR_eC'}} = \frac{\overline{\Delta V}\quad pR_eC}{1 + pR_e\,(C + C')}$$

Neglecting R'' the current change Δi produced by the voltage change ΔV will be given by:

$$\overline{\Delta i} = G_m \frac{\overline{\Delta V}\quad pR_eC}{1 + pR_e\,(C + C')}$$

$$\therefore \overline{\Delta V}/\overline{\Delta i} = \left(\frac{C' + C}{C} + \frac{1}{pR_eC}\right) 1/G_m$$

The output impedance thus consists of a resistance $\left(\dfrac{C' + C}{C}\right)1/G_m$ in series with a capacitance R_eCG_m.

In parallel with this combination will be the output resistance of the amplifier R''.

If R_e is sufficiently large the capacitive part of the output impedance can be ignored. Then:

$$Z_{out} = \frac{R''\left(\dfrac{C' + C}{C}\right)1/G_m}{R'' + \left(\dfrac{C' + C}{C}\right)1/G_m}$$

Approximate values for the parameters β, G_m, etc. are given in Table 1 for both practical circuits.

TABLE 1

Approximate values of design parameters for both practical circuits

PARAMETER	TRIODE CIRCUIT (FIG. 5)	PENTODE CIRCUIT (FIG. 6)
β—gain of input cathode-follower ..	0·9	0·9
G_m—transconductance of amplifier A	0·3mA/V	125mA/V
R''—output resistance of amplifier A	27kΩ	400Ω
R_e—leakage resistance from point z	Values vary for different diodes but are normally greater than 2MΩ	
α—gain of amplifier A	8	50
C—storage capacitance	22pF	22pF
C'—stray capacitance from point z to earth	~10pF	~10pF
Z_{out} calculated for S closed ..	6kΩ	17Ω
Z_{out} calculated for S open (neglecting R_e)	5kΩ	12Ω
Z_{out} measured (corresponding to Z_{out} for S closed)	7kΩ	17Ω
Leakage time constant (when R_e = 2MΩ)	0·5msec	2msec

REFERENCE

1. MACKAY, D. M. British Patent Application 14482/54.

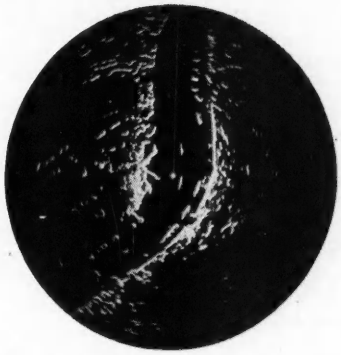
A New Low Cost Marine Radar

OVER the past five years Decca Radar have introduced a series of high performance marine radar sets designed to meet the requirements of a wide range of shipping.

The majority of ships in the medium and large tonnage groups have now been fitted, but there is an increasing demand from owners of small ships for a set which will give them the benefits of radar navigation. It is primarily to meet this demand that Decca have developed their new equipment, the Decca 212, which has been designed to meet the rigorous and well tested demands of the British Ministry of Transport Marine Radar Specification.

It consists of three simple radar units, comprising a scanner and its associated turning motor, a radar frequency unit in which is included the magnetron, klystron and mixer, and a display unit with a 9in fixed focus cathode-ray tube.

The scanner unit has been designed for low top weight, and the total weight is of the order of 75lb. This low weight unit



River navigation on the one-mile range.

produces a narrow beam of 1·7° for high picture quality, with a very low side lobe level for good performance in narrow waters. The r.f. unit provides an output of 10kW with dual pulsing for solid paints at long range and crisp pictures at short range. It can be mounted below deck in smaller vessels or on larger vessels in a special waterproof box at the base of the mast.

A brief specification of the Decca 212 is given below:—

FREQUENCY BAND. Within the Marine Band 9 320 to 9 480Mc/s.

AERIAL SYSTEM

Reflector: A single parabolic cylinder aerial of approx. 4ft.
Rotation: Continuously rotating 24 rev/min.
Horizontal Beam: 1·75° at half power points.
Vertical Beam: 20° at half power points.
Side Lobes: Better than 22dB within ± 10° of the main beam. Better than 30dB outside ± 10° of the main beam.

PULSE CHARACTERISTICS

Peak Power: 10 kW (approx.).
Duration: 0·1 or 0·2μsec-pulse width. Selection automatically controlled from the range and anti-clutter switches.
Recurrence Frequency: 1 000 per second.
Pulse Generator: Triggered hard valve modulator driving a magnetron.

RANGE

Discrimination: 25 yards on shorter ranges.
Minimum: 30 yards or less.
Calibration Ring accuracy within 1 per cent of indicated range.

Range Scales and Calibration Rings.

Range scale	Calibration rings	Range scale	Calibration rings
¼ mile	1/5th mile	8 miles	2 miles
1 mile	1/5th mile	15 miles	2 miles
3 miles	½ mile	30 miles	5 miles

BEARING

Accuracy: Within 1°.

The Operation and Loading Characteristics of Valve Oscillators for Dielectric Heating

(Part 2)

By V. L. Atkins*

Effective Internal Impedance of an Oscillator

When a valve is operated over the essentially linear portion of its characteristic curve such as obtained under class-*A* conditions the output current can be expressed as follows:

$$I_a = \frac{\mu V_g}{R_L + r_a} \quad \ldots\ldots\ldots\ldots\ldots (49)$$

Under these conditions the valve can be regarded as acting as a generator having an internal impedance value of $r_a (= \mu/g_m)$ delivering an output voltage of value $\frac{\mu V_g R_L}{R_L + r_a}$ into an external load of value R_L. With class-*C* operation, however, the valve behaves in a more complex manner, the value of the internal impedance becoming a function of the angle of current flow $2\theta_a$.

The relation can be obtained by substituting for the value of V_g' as given by equation (22) in equation (34) and solving for I_a:

$$I_a = g_m/\pi \left(V_B + v_{g(max)} - \frac{V_o - v_{a(min)}}{\mu} \right)(\theta_a - \sin\theta_a \cos\theta_a) \quad \ldots\ldots\ldots\ldots (50)$$

but:

$$V_B + v_{g(max)} = V_g \quad \ldots\ldots\ldots\ldots (51)$$

and:

$$V_o - v_{a(min)} = I_a R_L \quad \ldots\ldots\ldots\ldots (52)$$

from which:

$$I_a = \frac{\mu V_g}{R_L + f_3(\theta_a) r_a} \quad \ldots\ldots\ldots\ldots (53)$$

where:

$$f_3(\theta_a) = \frac{\pi}{\theta_a - \sin\theta_a \cos\theta_a} \quad \ldots\ldots\ldots (54)$$

Thus the apparent internal resistance of a valve operating at an angle $2\theta_a$ is equal to $f_3(\theta_a)r_a$. Values of $f_3(\theta_a)$ are plotted in Fig. 3.

Operating Efficiency

The anode efficiency can now be computed in terms of R_L and $f_3(\theta_a)r_a$.

Anode efficiency =

$$\eta = P_{out}/P_{in} = \frac{I_a^2 R_L}{2V_o I_o} = \frac{I_a R_L}{2V_o} \cdot I_a/I_o \quad \ldots (55)$$

$$= \frac{\mu V_g R_L}{V_o(R_L + f_3(\theta_a) r_a)} \cdot f_1(\theta_a) \times 50 \text{ per cent} \quad \ldots\ldots\ldots\ldots (56)$$

Difficulty is usually experienced when endeavouring to establish accurately the performance of a power oscillator under varying conditions, as a change in a single parameter can affect most of the other parameters of the oscillating system. Furthermore, the operating characteristics of a valve are not linear over the full working range as required to obtain the maximum power output. Fortunately, however, various assumptions can be made which greatly simplify the working computations, and allow operating conditions sufficiently accurate for most practical purposes to be evolved.

The anode efficiency can be written as follows:

$$\text{Anode efficiency} = V_a/V_o \, \eta_a$$

where

$$\eta_a = 50 \cdot f_1(\theta_a) \text{ per cent} \quad \ldots\ldots\ldots\ldots (57)$$

This shows that the maximum theoretical efficiency that can be obtained for a given operating angle $2\theta_a$ is equal to η_a. This is known as the asymptotic efficiency, values of which are plotted in Fig. 5. The actual operating efficiency can be readily assessed by multiplying the asymptotic efficiency by the ratio of V_a/V_o or the factor $(1 - \tau)$.

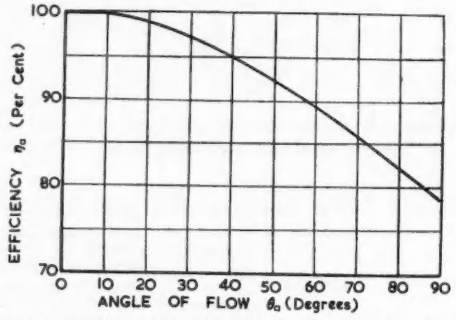


Fig. 5. Theoretical maximum efficiency of an oscillator as governed by the operating angle

Maximum Efficiency Operating Conditions

In the designing of a power oscillator it is necessary to fix the operating values of the minimum anode voltage $v_{a(min)}$ and the maximum grid voltage $v_{g(max)}$ which occur at the same instant. At this point the anode and grid currents reach peak value and the values of $v_{a(min)}$ and $v_{g(max)}$ are chosen so that the total peak current drawn equals or is slightly less than the maximum permissible emission of the cathode. Usually the value of $v_{a(min)}$ which should be slightly positive with respect to $v_{g(max)}$, is arranged to lie between 5 per cent and 10 per cent of the h.t. supply voltage V_o and $v_{g(max)}$ between 2 per cent and 8 per cent of V_o. Saturation occurs when $v_{g(max)}$ equals $v_{a(min)}$ and on no account is the value of $v_{g(max)}$ allowed to exceed $v_{a(min)}$, otherwise the grid current becomes excessive resulting in overheating of the grid electrode. If the ratio of $v_{a(min)}/V_o$ is made large both output power and efficiency are reduced, while the grid loss is increased. On the other hand the value of $v_{g(max)}$ cannot be made too small, otherwise the drive becomes insufficient for maximum conditions. The problem then remains to determine the values

* *Metropolitan-Vickers Electric Co., Ltd.*

of $v_{a(min)}$, $v_{g(max)}$, the load impedance and operating angle which will deliver maximum output for a given loss as governed by the valve design and construction. By taking the limiting conditions where $v_{a(min)}$ equals $v_{g(max)}$ as a reference level then a solution to the problem can be evolved as follows

At saturation:

$$v_{g(max)} = v_{a(min)} \quad \ldots\ldots\ldots\ldots \quad (58)$$

from which:

$$V_g = V_o - I_a R_L + V_B \quad \ldots\ldots\ldots\ldots \quad (59)$$

substituting for V_B as derived from equations (21) and (22)

$$V_g = \frac{V_o(1 + 1/\mu) - I_a R_L(1 + \cos\theta_a/\mu)}{1 - \cos\theta_a} \quad \ldots\ldots\ldots \quad (60)$$

substituting this expression in equation (53) and solving for I_a:

$$I_a = \frac{V_o(1 + \mu)}{R_L(1 + \mu) + r_a(1 - \cos\theta_a)f_3(\theta_a)} \quad \ldots\ldots\ldots \quad (61)$$

calling $\dfrac{1 + \mu}{r_a} = \rho$ and $f_3(\theta_a)\,(1 - \cos\theta_a) = f_4(\theta_a)$ then:

$$I_a = \frac{\rho V_o}{\rho R_L + f_4(\theta_a)} \quad \ldots\ldots\ldots\ldots \quad (62)$$

the function $f_4(\theta_a)$ is plotted in Fig 3.

The power output can be expressed thus:

$$P_{out} = \left(\frac{\rho V_o}{\rho R_L + f_4(\theta_a)}\right)^2 R_L/2 \quad \ldots\ldots\ldots \quad (63)$$

and the power input as:

$$P_{in} = \frac{\rho V_o^2}{f_1(\theta_a)(\rho R_L + f_4(\theta_a))} \quad \ldots\ldots\ldots \quad (64)$$

where

$$f_1(\theta_a) = \frac{\theta_a - \sin\theta_a \cos\theta_a}{\sin\theta_a - \theta_a \cos\theta_a}$$

therefore the power loss becomes:

$$P_a = V_o^2 \rho \left(\frac{1}{f_1(\theta_a)(\rho R_L + f_4(\theta_a)} - \frac{\rho R_L}{2(\rho R_L + f_4(\theta_a))^2}\right) \ldots \quad (65)$$

$$= V_o^2 \rho \ \Psi(\theta_a, \rho P_L) \quad \ldots\ldots\ldots\ldots \quad (66)$$

The efficiency at saturation can be written as:

$$\eta_{(sat)} = \frac{f_1(\theta_a)\, I_a R_L}{2V_o} \quad \ldots\ldots\ldots\ldots \quad (67)$$

$$= \frac{f_1(\theta_a)\, \rho R_L}{2(\rho R_L + f_4(\theta_a))} \quad \ldots\ldots\ldots\ldots \quad (68)$$

$$= f(\theta_a, \rho R_L) \quad \ldots\ldots\ldots\ldots \quad (69)$$

The function Ψ is a constant which can be applied to all valves and can be computed once the anode voltage V_o and power loss P_a have been selected, i.e.:

$$\Psi = P_a / V_o^2 \rho \quad \ldots\ldots\ldots\ldots \quad (70)$$

By plotting values of Ψ and $\eta_{(sat)}$ as functions of θ_a and ρR_L as shown in Fig. (6) and projecting vertical lines from the intersections obtained on the Ψ family of curves for a constant value of Ψ, to the corresponding values of θ_a in the $\eta_{(sat)}$ family of curves, the values of θ_a and ρR_L which give maximum efficiency conditions can be ascertained. Determining the value of $v_{a(min)}$ $(= v_{g(max)})$ at the optimum conditions is simply obtained from the relation:

$$v_{a(min)} = V_o - I_a R_L \quad \ldots\ldots\ldots\ldots \quad (71)$$

which written in terms of ρR_L and θ_a becomes:

$$v_{a(min)} = V_o \left(1 + \frac{\rho R_L}{\rho R_L + f_4(\theta_a)}\right) \quad \ldots\ldots\ldots \quad (72)$$

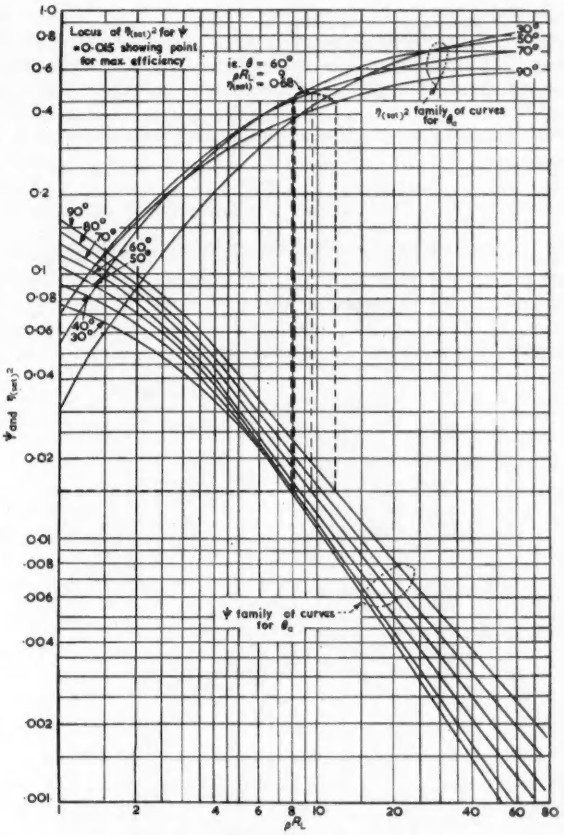

Locus of $\eta_{(sat)}^2$ for Ψ = 0·085 showing point for max. efficiency
ie. θ = 60°
ρR_L = 9
$\eta_{(sat)}$ = 0·68
$\eta_{(sat)}^2$ family of curves for θ_a
Ψ family of curves for θ_a
Ψ and $\eta_{(sat)}^2$
ρR_L

Fig. 6. Universal characteristics for designing power oscillators Ψ being a function of the anode voltage and the maximum permissible anode dissipation, ρ being a function of the amplification factor and internal impedance of the valve

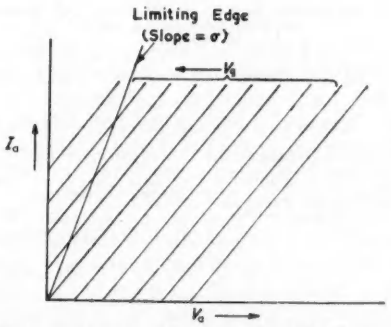


Fig. 7. "Ideal" set of I_a/V_a characteristic curves for triode valve showing the limiting edge where $V_a = V_g$

Examination of the curves drawn in Fig. 6 shows that the efficiency at optimum conditions is greater the smaller the value of Ψ. This requires the value of V_o to be the maximum possible and shows that for a given loss the greater the amplification factor (μ) and smaller the r_a of the valve, greater will be the power output and efficiency.

Over the normal working range of a valve the grid family of I_a/V_a characteristic curves can be taken to be linear and it can be assumed for practical purposes that the line on which they terminate where $v_a = v_g$ will also be straight

passing through the point of origin. This is illustrated in Fig. 7. Calling the slope of this limiting edge σ then the peak current drawn can be expressed as follows:

$$i_{a(pk)} = \sigma v_{a(min)} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (73)$$

Now at saturation the fundamental alternating current component is:

$$I_a = \frac{\rho V_o}{\rho R_L + f_4(\theta_a)} \quad \ldots\ldots\ldots\ldots \quad (74)$$

In terms of the peak current the expression becomes:

$$i_{a(pk)} = \frac{\rho V_o}{\rho R_L + f_4(\theta_a)} \cdot f_2(\theta_a)/f_1(\theta_a) \ldots\ldots \quad (75)$$

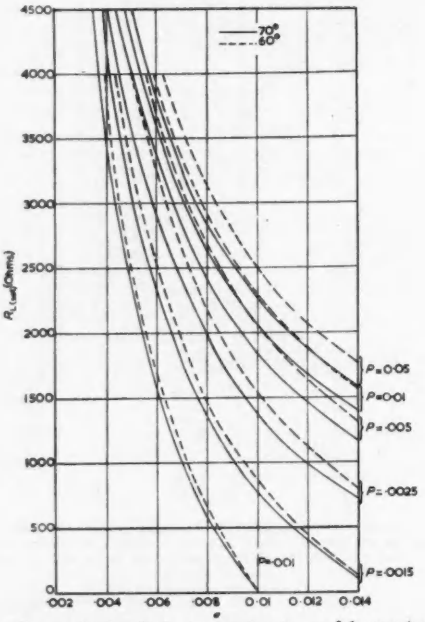


Fig. 8. Curves showing load at saturation for $\tau = 0{\cdot}1$ assuming ideal linear characteristics of Fig. 7

Substituting for equation (73) and evaluating in terms of the load R_L:

$$R_L = [V_o/\sigma v_{a(min)} \cdot f_2(\theta_a)/f_1(\theta_a)] - f_4(\theta_a)/\rho \quad \ldots \quad (76)$$

Under normal operating conditions the ratio of $V_o/v_{a(min)}$, $(1/r)$ approximates to 10, thus the load at saturation can be expressed as follows:

$$R_{L(sat)} = [10/\sigma \times f_2(\theta_a)/f_1(\theta_a)] - f_4(\theta_a)/\rho \text{ approx.} \ldots \quad (77)$$
$$= f_4(\theta_a) \ (10/\sigma - 1/\rho)$$

For a valve of known constants σ and ρ, the relation gives for a specific operating angle the minimum value of load into which the valve can work before reaching saturation. Normally the load is designed to be slightly higher. Curves giving values of $R_{L(sat)}$ at operating angles of 60° and 70° for different values of σ and ρ are shown in Fig. 8.

Loading Characteristics of a Valve Oscillator

As shown later an inherent feature of a self-excited oscillator employing self-bias is that under normal operating conditions the value of V_a which almost reaches the value of the d.c. supply voltage V_o, only slightly reduces when the load is varied from no-load to full load conditions. Thus in the equation of anode efficiency (equation (56)) the part in parenthesis will tend to approach unity and the value of V_g which represents the proportion of the anode oscillation fed back to the grid, can be assumed as remaining substantially constant. With μ, V_o and r_a being constants, $f_3(\theta_a)$ becomes a function of R_L which thus determines the operating angle $2\theta_a$. As the value of the operating angle is controlled by the amount of the grid bias voltage V_B (V_g remaining constant in this case) then it follows that equilibrium conditions of the oscillating system are obtained when the grid bias voltage V_B reaches a value such that

$$\frac{\mu V_g R_L}{V_o(R_L + f_3(\theta_a) r_a)}$$

approximates to unity. Equating the expression to unity and solving for the value of $\mu V_g/V_o$

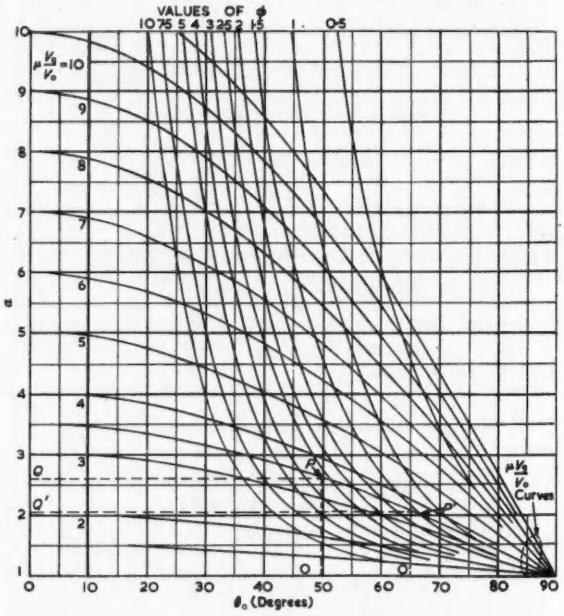


Fig. 9. Functions of α for analysis of the loading characteristics of an oscillator. The dotted lines refer to cross co-ordination with Fig. 11

$$\mu V_g/V_o = \frac{R_L + f_3(\theta_a) r_a}{R_L} \quad \ldots\ldots\ldots\ldots \quad (78)$$

and calling the ratio R_L/r_a, ϕ

$$\mu V_g/V_o = (\alpha + \tau) = 1 + f_3(\theta_a)/\phi \quad \ldots\ldots \quad (79)$$

From equations (21) and (22) $\mu V_B/V_o$ can be expressed in terms of $\mu V_g/V_o$ and θ_a and again taking the value of V_a/V_o to be unity, then:

$$\mu V_B/V_o = (\mu V_g/V_o - 1) \cos\theta_a + 1 \quad \ldots\ldots \quad (80)$$

Substituting for $\mu V_g/V_o$ in equation (79) a further relation for $\mu V_B/V_o$ is obtained, viz:

$$\mu V_B/V_o \ \frac{f_3(\theta_a) \cos\theta_a}{\phi} + 1 \quad \ldots\ldots\ldots\ldots \quad (81)$$

In applying these relations it must be appreciated that they are based on the assumed "ideal" conditions where V_a becomes equal to V_o, whereas in practice this is not the case. Furthermore the relation cannot hold for all values of V_g and ϕ owing to the limiting conditions reached at saturation or where insufficient grid current is drawn to provide the necessary bias required for class-*C* operation. The value of V_g is also limited by the maximum grid power loss. The relations do, however, form a basis upon which the loading characteristics for a particular valve may be evolved. For

having determined the value of V_g, the values of ϕ and $\mu V_B/V_o$ (α) for a given operating angle can be easily assessed. The plotting of a series of curves based on equations (80) and (81) as shown in Fig. 9 will indicate how for a constant value of $\mu V_g/V_o$ the values of α and θ_a vary with respect to ϕ. On the assumption that the amplitude of the grid voltage (V_g) remains fairly constant for a reasonable "falling off" in load from maximum value, and providing the correct drive conditions are operating, then a useful relation between load and grid bias voltage is obtained. Thus a quantitative indication of a changing load is provided, once the operating conditions for a specific load are established and changes in the grid current are then observed with a change in load.

In designing a power oscillator it is necessary to establish the optimum value of anode load required to deliver the desired amount of power for specific operating conditions. The optimum value as chosen is based on obtaining a reasonable compromise between efficiency and power output. In practice efficiencies of between 60 per cent and 80 per cent are usually demanded to obtain maximum output as limited by the anode dissipation and peak filament emission of the valve. In order to obtain optimum loading conditions, the impedance (resistance) presented to the valve by the tank circuit must be equal to V_a/I_a, where I_a is the maximum value as permitted by the selected operating angle. Designating the optimum values by the suffix (opt) then:

$$R_{L(opt)} = V_a/I_{a(opt)} = Q_{(opt)}\, L_{(opt)}\omega \quad \ldots\ (82)$$

and the optimum value of the tank inductance will be:

$$L_{(opt)}\ R_{L(opt)}/Q_{(opt)}\omega \quad \ldots\ (83)$$

Under optimum loading conditions the peak filament emission which is determined by the values of $v_{a(min)}$ and $v_{g(max)}$, reaches its maximum permissible value. The optimum value of $R_{L(opt)}$ can be expressed in terms of $i_{a(pk)}$ as follows:

$$R_{L(opt)} = V_a/i_{a(pk)} \cdot \left(\frac{(1 - \cos\theta_a}{\theta_a - \sin\theta_a \cos\theta_a}\right) \quad \ldots\ (84)$$

at optimum conditions $V_a \simeq V_o$.

$$\therefore\ R_{L(opt)}\ V_o/i_{a(pk)} \cdot \left(\frac{(1 - \cos\theta}{\theta_a - \sin\theta_a \cos\theta_a}\right) \quad \ldots\ (85)$$

$$= V_o/i_{a(pk)}\ .\ f_4(\theta_a)\ \text{(approx.)} \quad \ldots\ (86)$$

Values of $R_{L(opt)}$ for varying values of $V_o/i_{a(pk)}$ and operating angle θ_a are plotted in Fig. 10.

Departure from the optimum value results in either a reduction of power output or overloading of the valve when the load becomes excessive. The behaviour of a power oscillator under varying load conditions calls for special consideration when designing equipment for high frequency heating, as in most applications the load varies considerably.

The value of the a.c. voltage V_a, ($V_o - v_{a(min)}$) developed across the tank circuit depends upon the values of the fundamental a.c. current component I_a and the load impedance R_L. Under light load conditions the value of V_a will be at its maximum value, while the value of I_a will be at its minimum value. As the value of the load increases (i.e. R_L reduces) towards optimum value, V_a will tend to become less, while I_a will increase in order to supply the extra power to the tank circuit. The increase in the value of I_a is brought about by an increase in the angle of current flow $2\theta_a$ which also increases the average input power. This arises from the fact that as the value of V_a reduces and the grid drive becomes less, the grid voltage $v_{g(max)}$ becomes relatively less positive with respect to the cathode, causing the value of the grid current to fall. This in turn reduces the value of the grid bias voltage V_B which causes the value of the grid voltage $v_{g(max)}$ and the operating angle θ_a to increase. The action is self-adjusting, the bias level changing until new conditions of equilibrium are reached, where the increase in I_a obtained is sufficient to supply the increase in power required. With the anode current being thus sensitive to changes in the value of $v_{a(min)}$, the amplitude of oscillation tends to remain substantially constant for reasonable changes in load. Thus the oscillator can be regarded as being virtually a constant output voltage generator, having an internal e.m.f. of μV_g volts. In practice the amplitude of V_a varies from approximately 95 per cent to 90 per cent of the d.c. supply voltage V_o when the

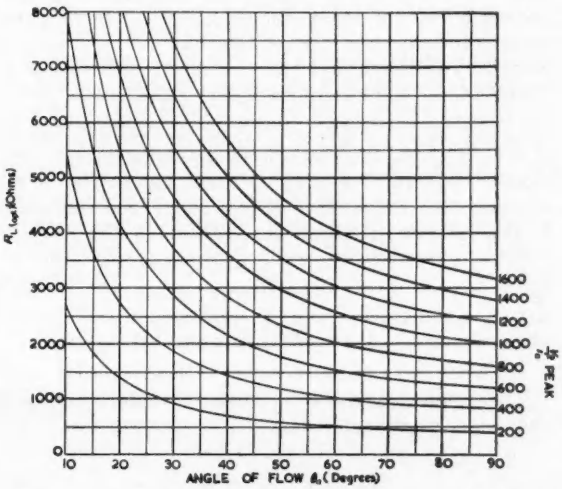


Fig. 10. Curves giving approximate value of optimum load for different value θ_a and $V_o/i_{a(pk)}$

load is varied from no-load to full-load conditions. The value of V_a can never reach the value of V_o as this would give rise to conditions of no anode current flow and the grid current becoming dangerously excessive. On the other hand if the valve is loaded beyond its optimum rated output, saturation of the filament emission is reached and the value of I_a can no longer increase, with the result that the value of V_a falls and so increases the power dissipated at the anode resulting in the valve becoming overheated.

Although variation of load between no-load and full-load conditions causes only a slight reduction in the value of V_a, the change which occurs to both power output and anode efficiency is considerable. The effects which are readily observed when the load increases are the increase in the d.c. input current and the reduction in the grid current flow. What is not so obvious is the increase in the angle of flow of $2\theta_a$, which, apart from increasing the power input, changes the operating efficiency. As $2\theta_a$ and I_o increase, the ratio of I_a/I_o also increases and thus the proportion of the increase in power input which is dissipated in the valve becomes greater, while the proportion which is delivered to the load becomes correspondingly less. If the load remains constant an increase in the grid excitation voltage V_g will cause the bias voltage V_B and the maximum grid voltage $v_{g(max)}$ to increase and the oscillation will assume a new point of equilibrium at a

reduced angle of flow. The grid loss will increase, but the anode efficiency will improve slightly, owing to the fact that with the amplitude of the output voltage V_a tending to remain constant, the fundamental alternating current component I_a will also remain fairly constant. Thus with the reduced angle of flow the direct current component I_o will be reduced and as a result so will the power input. The value of $v_{g(max)}$ is, of course, limited to the point when the valve becomes overdriven, where apart from causing over dissipation of power in the grid circuit, the anode current waveform becomes considerably distorted and the algebraic analysis as used to determine the operating conditions of the valve can no longer be applied.

Determination of Valve Operating Conditions

The effect which variable loading has on the operating performance of a power oscillator needs to be examined closely, and is one of the major problems associated with the design of h.f. heating equipment. An approximate method showing how the performance of an oscillator reacts to a changing load can be evolved fairly readily if it is assumed that little change occurs to both output voltage and frequency for reasonable variations in load. For under such conditions the power dissipated in the tank circuit will be inversely proportional to the value of the load resistance R_L, which includes the circuit losses. Thus if the optimum load resistance is termed $R_{L(opt)}$ and the actual loading resistance is termed $R_{L(act)}$, then:

Power dissipated in load/optimum power available

$$= R_{L(opt)}/R_{L(act)} \quad \ldots\ldots\ldots\ldots \quad (87)$$

If $I_{a(opt)}$ and $I_{a(act)}$ represent the optimum and actual values of the fundamental a.c. currents respectively,

$$R_{L(opt)}/R_{L(act)} = /I_{a(opt)} \quad \ldots\ldots\ldots \quad (88)$$

Applying this relation to equation (53) and assuming a constant value of grid voltage:

$$I_{a(opt)}\,(R_{L(opt)} + f_3\,(\theta_{a(opt)})\,r_a) = I_{a(act)}\,(R_{L(act} + f_3\,(\theta_{a(act)})\,r\,) \ldots\ldots\ldots \quad (89)$$

with:

$$I_{a(opt)}\,R_{L(opt)} = I_{a(act)}\,R_{L(act)} = V_a \text{ (assumed constant)}$$

$$I_{a(act)}/I_{a(opt)} = f_3(\theta_{a(opt)}))/f_3(\theta_{a(act)}) \ldots\ldots \quad (90)$$

where $f_3(\theta_{a(opt)})$ and $f_3(\theta_{a(act)})$ are the functions of the optimum and actual operating angles $\theta_{a(opt)}$ and $\theta_{a(act)}$ respectively. In terms of the direct current components the relation can be written as:

$$I_{o(opt)}/I_{o(act)} = \psi_{(opt)}/\psi_{(act)} = f(\theta_{a(opt)})/f(\theta_{a(act)}) \ldots. \quad (91)$$

where $\psi = \sin\theta_a - \theta_a \cos\theta_a$.

From this relation a series of curves can be plotted as shown in Fig. 11 giving values of $\theta_{(act)}$ as against $\theta_{(opt)}$ for different values of $I_{o(act)}/I_{o(opt)}$.

To a certain limited extent this set of curves can be used in conjunction with those of Fig. 9 to provide a means of establishing approximately the operating conditions of a valve oscillator when the value of the grid voltage V_g, the load R_L and the flow angle are not known; factors which in practice are not always easily measured.

In order to derive the operating conditions with the help of these graphs all that is required is the values of the anode and grid currents for two different loading conditions of the valve with constant grid drive. Although it is not essential that one of the loaded conditions be the optimum value, satisfactory results will only be obtained provided the oscillator is working within the limiting conditions as previously specified. It is usually fairly easy to vary the loading of a power oscillator, in fact in general the reverse is the case, it being difficult to maintain constant loading owing to changes in the characteristics of a load during a heating cycle. To find the co-ordinates on the graph of Fig. 9 which will indicate the operating conditions, it is first necessary to determine the values of $\alpha(=\mu V_B/V_o)$ for at least two different loading conditions with the value of V_g remaining constant. Knowing the values of the grid bias resistor, μ and V_o, the values of α are easily assessed from the respective grid currents. Having established the two α ordinates it remains for the appropriate θ_a abscissæ to be determined in order to fix the operating points. The ratio of the corresponding anode currents gives the ratio of the functions of ψ, from which, with the aid of the

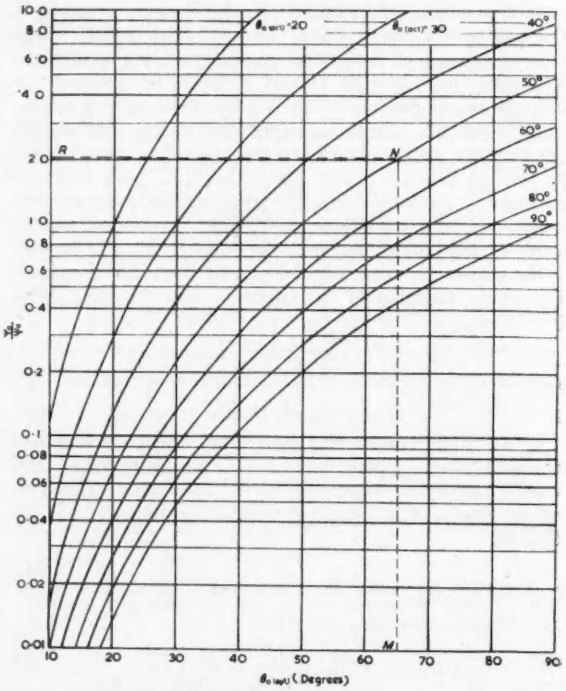


Fig. 11. Values of ψ_o/ψ_a giving the ratio of the d.c. currents obtained with a change in the angle of flow from $\theta_{a(opt)}$ to $\theta_{a(act)}$ (or $\theta_{(act)}'$ to $\theta_{(act)}''$). This family of curves used in conjunction with those of Fig. 9 allow the operating conditions of a valve oscillator to be followed with variation in load. An example of the method is illustrated by the dotted lines

curves of Fig. 11, the two operating angles which satisfy the relations of both graphs may be evolved. The co-ordinates of the two operating points must lie on the same $\mu V_g/V_o$ curve of the graph of Fig. 9, $\mu V_g/V_o$ being assumed to remain constant, while the corresponding θ_a co-ordinates on the graph of Fig. 11 must intersect on the correct $\psi_{(opt)}/\psi_{(act)}$ ordinate. The method is illustrated by the dotted lines OP, O′P′ and QP, Q′P′ shown in Fig. 9 which represent respectively the two sets of the $\mu V_B/V_o$ and θ_a co-ordinates, the values of θ_a corresponding to $\theta_{a(act)}$ and $\theta_{a(opt)}$ values as fixed by the co-ordinates MN, RN, as shown in Fig. 11. P, P′, (Fig. 9) denotes the two operating points which lie on the constant $\mu V_g/V_o$ line from which the value of V_g may be determined. The intersections made with the ϕ series of curves allow the two different values of the load R_L to be found. The use of these graphs in the

manner as outlined can greatly assist the initial setting-up of a power oscillator. Furthermore, as reasonable changes in load (this includes circuit losses) may be ascertained, the graphs will be of particular use in dealing with the many applications met in practice where the load varies with change of temperature or moisture content etc. Obviously the problem is greatly simplified if the value of V_g is known, for then it is simply a matter of reading off values of θ_a and ϕ along the appropriate $\mu V_g/V_o$ line for the various values of a obtained. Thus the anode current ratio curves of Fig. 11 would not be required.

Based on the assumption that the value of the alternating current component I_a and the anode voltage swing V_a remain substantially constant for slight changes in the grid drive voltage V_g, the relation between changes in the d.c. anode current with variation of grid drive for a constant load can be easily shown to be:

$$I_{o(opt)}/I_{o(act)} = f_1(\theta_{a(act)})/f_1(\theta_{a(opt)}) \quad \ldots (92)$$

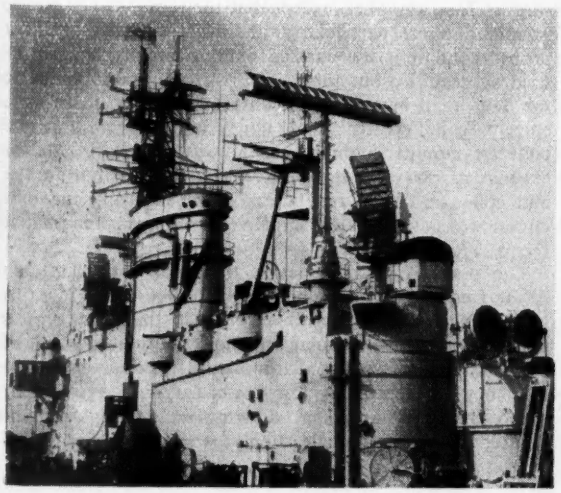
From this relationship a similar set of curves to those of Fig. 11 may be derived and so enable the operating points to be determined in the same manner as the previous case except that the curves of constant value will be those of the factor ϕ. As previously explained the above treatment is restricted in operation to within certain limits of load variation. In practice this can be regarded as varying from light load conditions where the grid current drawn does not exceed the maximum permissible value to full (optimum) load conditions which consists of the working load plus the circuit losses. It is not essential to consider the behaviour of the operating conditions when the load is in excess of the optimum value as in general the equipment is so designed that it is fully protected from becoming overloaded.

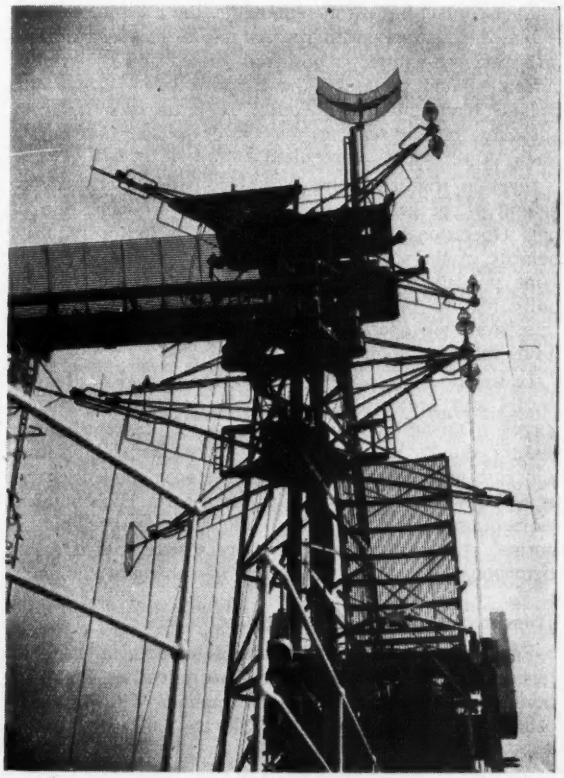
A simple method which increases the amount of variable loading a valve oscillator can safely handle is obtained by arranging the grid bias resistor to have a non-linear characteristic possessing a positive coefficient. As previously mentioned, the maximum loading point is limited to the optimum value while the minimum loading point is limited to the maximum value of grid current. If the characteristic of the grid resistor is such that an increase in current increases the resistance and thereby increases the bias voltage, the minimum value of load, which can be imposed for the maximum value of grid current will be increased. It also means that for slight changes in load the grid current will tend to remain constant. In practice normal tungsten filament lamps are used operating at approximately half of their normal brightness.

Having now dealt with the operating characteristics of the valve oscillator under varying load conditions, it remains to investigate the problems associated with the transfer of power from the tank circuit to the load, and show how mismatching of the load impedance, linked with the circuit transfer efficiency, governs the overall performance of the equipment. This, together with typical power oscillator and work circuits, methods and control of power loading form the subject of a further article to be published at a later date.

THE AERIAL ARRAY OF A MODERN BATTLESHIP

The importance of radio and radar in modern naval warfare is exemplified by the accompanying photographs which show part of the aerial installation on the fighting control tower of H.M.S. Ark Royal the new 36 800 ton aircraft-carrier which was commissioned at Birkenhead in February.





Transistor Waveform Generators

By F. Butler, B.Sc., M.I.E.E., M.Brit.I.R.E.

The characteristics of currently available transistors are so variable that the precise design of oscillator and pulse generator circuits is often impracticable. Many circuits can best be devised by making use of the analogy between transistor amplifiers and their valve-operated counterparts.

Descriptions are given of several experimental oscillators which have been developed by making use of these principles. They include tuned-circuit, crystal controlled and blocking oscillators.

A GREAT deal of published work has appeared on the physics of point-contact and junction transistors and equivalent circuits have been derived from which the performance of idealized linear amplifiers may be predicted. The design problem is complicated because of wide variations in the characteristics of available transistors, nominally of the same type, and it is commonly found that individual adjustment of component values is required to meet a given specification. Because of this lack of uniformity in characteristics there are many transistor circuits which can best be devised by making intelligent use of a rather loose correspondence which exists between these and certain well-known valve circuits. It is the object of this article to describe a few useful oscillator and pulse generator circuits, mostly developed by cut-and-try methods aided by simple reasoning from the principles just mentioned.

Transistor Operation

Point-contact transistors require that the collector element is biased negatively with respect to the base. In normal operation the emitter is positively biased and the emitter current should preferably be supplied from a high impedance (constant current) source. As in the case of valves, automatic biasing schemes may be devised so that only a single power supply is required.

Junction transistors are assembled from specimens of n- and p-type germanium, either in the sequence npn or pnp. Operationally the only difference is in the requisite polarity of the supply source. The pnp units call for the same polarity as the point-contact types while the npn units require that the batteries are reversed. Junction transistors will operate successfully at much lower power levels than the point-contact types.

Transistor units of all types have a very low thermal inertia and are easily damaged by momentary current surges. During development work a current-limiting resistor should be connected in the power supply leads and care must be taken to avoid the accidental discharge of a large capacitor through the transistor. High ambient temperatures adversely affect the performance but in normal practice no trouble need be experienced if a few elementary precautions are taken to safeguard the units.

Transistor Amplifier Characteristics

Fig. 1 shows two amplifier circuits suitable for use with junction transistors. The earthed-base circuit in Fig. 1 (a) resembles an earthed-grid valve amplifier. The input impedance is low (of the order 200 to 500Ω), the output impedance is very high and there is no phase change between the input and output voltages. The earthed emitter circuit shown in Fig. 1 (b) is similar to an earthed cathode valve amplifier. The input impedance is considerably higher than in the previous case, the power gain is greater and the output voltage developed across the load resistance R is reversed in phase as compared with the driving voltage. In most cases this circuit is preferable to the earthed base alternative. The third possible circuit, employing an earthed collector, is not of particular interest in the present connexion.

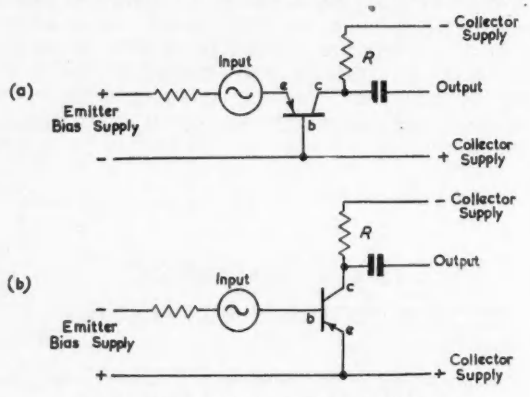


Fig. 1. Pnp junction transistor amplifiers
(a) Earthed base circuit *(b) Earthed emitter circuit*

The point-contact transistor is quite satisfactory as an earthed base amplifier, except that the signal-to-noise ratio is rather poor, particularly at low frequencies. Under proper conditions the earthed emitter circuit can also be used successfully but there is a risk of instability due to the fact that in the point-contact transistor there is a current gain greater than unity between emitter and collector circuits. Stability can always be secured, at the expense of power gain, by increasing the external emitter and collector circuit resistances or by reducing the base circuit resistance which effectively reduces the positive feedback.

The power gain of junction transistor amplifiers falls off at frequencies higher than about 20kc/s but in other respects the performance is superior to that of the point contact type. In particular the noise output is low and both amplifiers and oscillators will function with high efficiency at exceedingly low power levels. A typical pnp audio frequency amplifier, deriving collector power and emitter bias from a single supply, is shown in Fig. 2.

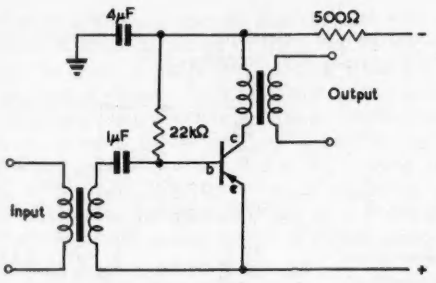


Fig. 2. Earthed emitter amplifier employing pnp transistor

Transistor Oscillators

Provided that the power gain is large enough any tuned amplifier can be converted into an oscillator by coupling the output back to the input circuit. It is of course essential to arrange that the phase of the feedback voltage is in the correct sense to sustain oscillation. In a valve oscillator the a.c. conditions are satisfied by connecting the grid and anode leads to the opposite ends of the main tuned circuit while the cathode tap is taken to an intermediate point. The ratio of the voltage drop between anode and cathode to that between grid and cathode is equal to the stage gain of the valve and its associated circuit. All tuned-circuit oscillators of the three-terminal type satisfy these conditions and practical arrangements merely require the provision of d.c. feed and grid bias. Similar arguments apply even when a separate reaction or coupled winding is used instead of a tapped tuned circuit.

Transistor oscillators can be developed from similar considerations. Correct a.c. conditions are secured when the collector and base are connected to opposite ends of the tuned circuit while the emitter lead is taken to an intermediate point. A single earth connexion may be made to any point of the system without affecting its operation. In any type of oscillator the waveform is most nearly sinusoidal when the regeneration is set so that oscillations are barely sustained. The stability of frequency is greatest when the tuned circuit is very loosely coupled to the maintaining system, (valve or transistor).

The oscillator circuits so far discussed are of the conventional three-terminal variety but two-terminal negative resistance valve oscillators can be devised, employing dynatron or transitron circuits. A two-terminal point-contact transistor oscillator of this type is also known. It makes use of the negative resistance which exists between the base and the other electrodes when low (or zero) resistances are externally connected in the emitter and collector circuits.

Three tuned-circuit oscillators employing pnp junction transistors are shown in Fig. 3. Component sizes are given so that the circuits may be adapted for use at other frequencies by making proportional changes in all the element values. The best arrangement is that given in Fig. 3(c), in which the transistor is very loosely coupled to the primary tuned circuit. The observed waveform is extremely good and the power efficiency very high. This circuit works satisfactorily from a single dry cell, under which conditions the total current drain is less than 1mA.

Many similar circuits can be devised, all making use of the same basic principles and all giving a comparable performance.

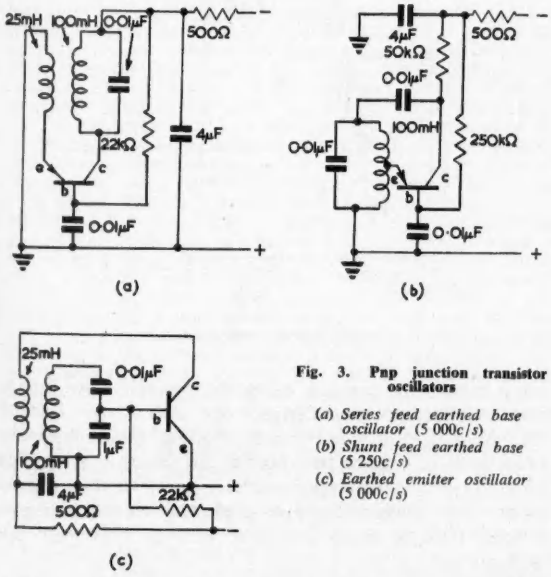


Fig. 3. Pnp junction transistor oscillators

(a) *Series feed earthed base oscillator* (5 000c/s)
(b) *Shunt feed earthed base* (5 250c/s)
(c) *Earthed emitter oscillator* (5 000c/s)

Crystal Controlled Oscillators

It has already been remarked that the performance of junction transistor amplifiers falls off at relatively low radio frequencies, but there is no particular difficulty in designing circuits with sufficient gain to ensure reliable working of quartz oscillators up to about 100kc/s, using crystals of high activity. There is little or no published work on transistor drive circuits for use with low frequency flexural mode quartz vibrators using bars or ring crystals operating in the range 1 to 20kc/s. The theory of these vibrators and the design of suitable valve maintaining circuits have already been described in detail[1]. Such arrangements represent the most economical method of generating a series of precisely known audio frequencies without the necessity for many complex stages of frequency division. For example, a 1000c/s ring crystal followed by one conventional decimal divider stage and two simple cold-cathode decade counters could be devised to generate a whole range of low frequencies and to provide one-second time marker pulses. Ring and bar vibrators can only be operated at a low power level without the risk of crystal fracture and this power limitation also applies to transistor operation. It is therefore of interest to develop suitable transistor drive circuits, together with frequency dividers which will also function at extremely low power levels. The electrode arrangement of a three-terminal quartz flexural vibrator is shown pictorially in Fig. 4(a) and schematically in Fig. 4(b). At its resonant frequency the system is represented approximately by a phase-reversing transformer of unity ratio, having a fairly high resistance in series with one of its windings. The equivalent circuit is shown in Fig. 4(c).

A suitable circuit for maintaining the bar in continuous vibration is shown in Fig. 5. It employs a point-contact transistor of which the emitter is earthed. Assuming that the circuit is working, there is an alternating voltage developed across the collector load resistor. This is applied to the crystal causing an attenuated voltage of reversed phase to appear across the output electrodes and also

across the main tuned circuit. A secondary winding provides the transistor driving voltage without further phase change. Self bias is provided by the *RC* combination in the base lead. By careful selection of the collector load resistance it is possible to raise the base circuit input impedance but there is a risk of instability if this becomes negative. In this case uncontrolled oscillations occur, the frequency of which depends on the *LC* product of the tuned circuit, and is unaffected by the presence of the

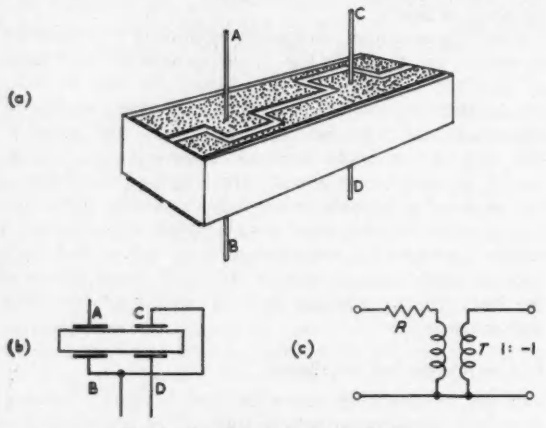


Fig. 4. Low frequency quartz vibrators
(a) Electrode arrangement of 3-terminal quartz flexural vibrator
A *and* D: *Free terminals*
B *and* C: *Cross connected*
(b) Schematic diagram of 3-terminal vibrator
(c) Simplified equivalent circuit at resonance

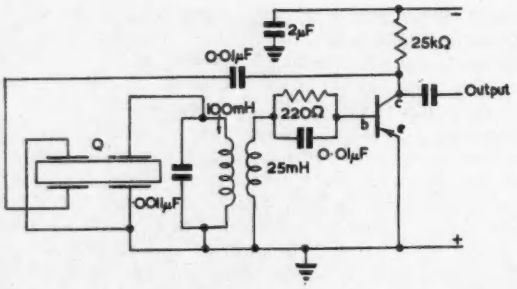


Fig. 5. Point-contact transistor oscillator with 15kc/s quartz vibrator

crystal. In practice, a fair amount of regeneration can be applied before instability is observed. Circuits employing positive feedback are not strictly designable and they are rightly suspect. Unfortunately the margin of reserve power gain of currently available transistors is so low that it is not always possible to avoid these subterfuges.

A circuit employing a junction transistor is shown in Fig. 6. It is somewhat difficult to set up because of the complex impedance matching and tuning adjustments which have to be made but its performance is otherwise superior to that of the arrangement shown in Fig. 5. If the two free electrodes of a three-terminal vibrator are coupled together the resulting two-terminal element can be used in any conventional crystal oscillator circuit. At its series resonant frequency the vibrator is electrically equivalent to a resistance of several thousand ohms. When used as a circuit element in a network it is evident that the vibrator will cause severe attenuation of output current and voltage unless the remaining network elements are of abnormally high impedance.

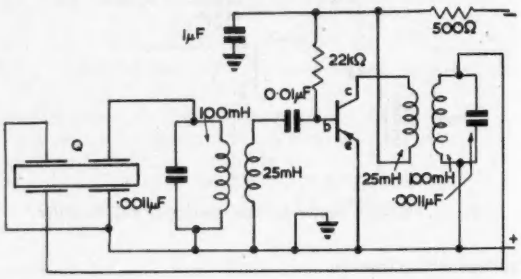


Fig. 6. Junction transistor oscillator with 15kc/s quartz vibrator

Blocking Oscillators

Point contact transistors which give a current multiplication factor of two or more have been employed in a wide variety of counter and divider circuits[2, 3]. Blocking oscillators employing junction transistors have received much less attention. Experience shows that they can be employed in simple circuits to give reliable operation with moderately high division ratios and at very low power levels. They are thus well suited for operation in conjunction with crystal controlled transistor oscillators.

One of the simplest circuits is given in Fig. 7. As shown, the arrangement is a self-running oscillator which produces a train of recurrent pulses the repetition frequency of which is primarily settled by the *RC* product in the base circuit. The pulses can readily be locked to an external signal at a multiple or sub-multiple frequency. Division ratios of about 15 are practicable, but for the highest stability the factor should be 5 or less. The damping diode connected across the primary winding of the transformer serves to prevent ringing and ensures that only a single pulse is produced during each cycle of operation. Trigger-

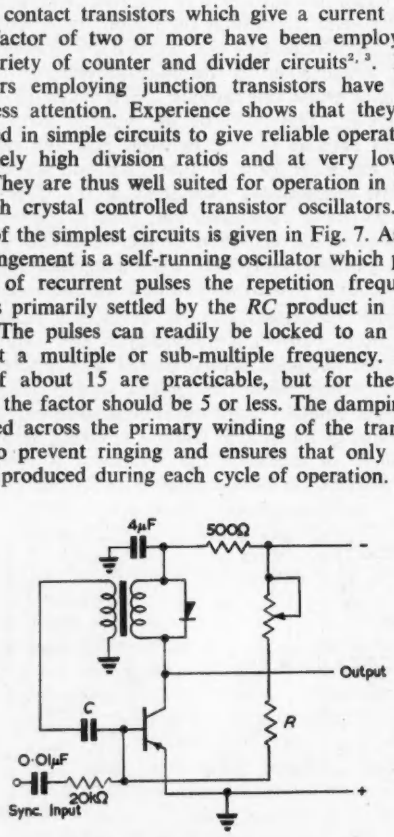


Fig. 7. Blocking oscillator using junction transistor

ing is easily achieved with either pulse or sine wave inputs. The transformer characteristics are in no way critical. The primary (collector circuit) winding should have an inductance of one or two henries for use at a frequency of 1kc/s. The secondary (emitter circuit) winding should be of rather lower inductance, preferably corresponding to a turns ratio of about 2:1. The winding resistances are unimportant.

The free-running frequency may be adjusted in steps

by switching different capacitors into the base circuit. Fine adjustment is made by means of the continuously variable resistor. Provision is made for injecting a locking signal into the emitter circuit. The component values shown are suitable for coupling the synchronizing terminal direct to the output terminal of the oscillator shown in Fig. 5.

The circuit of Fig. 7 works well at 5kc/s when drawing a total current of 200μA from a 2V collector supply. When the blocking oscillator is triggered at a sub-multiple frequency the output pulses appear in groups separated by definite spaces. It is easy to vary the spacing between pulse groups and to change the number of pulses in each group by altering the fundamental frequency of the blocking oscillator and by varying the sub-multiple locking frequency. This circuit is useful as a synchronous gating signal generator for periodically selecting any specified number of pulses from a stream of impulses such as might be employed in an electronic computor or communication system.

Conclusion

From the limited amount of experimental work described above, it appears that it should be possible to produce commercially a small battery-operated secondary standard of frequency consisting of a crystal oscillator and two or three blocking oscillator dividers, making available a wide range of precisely known audio frequencies. The range could be extended downwards by adding one or more cold-cathode counter tubes without reducing the reliability of the equipment, although at the expense of introducing circuit complications.

The performance of transistors is adversely affected by high temperatures and this disability tends to restrict their field of application. The power gain of currently available types is rather less than is desirable. It would be possible to simplify a number of the circuits described above if they could be improved in this respect.

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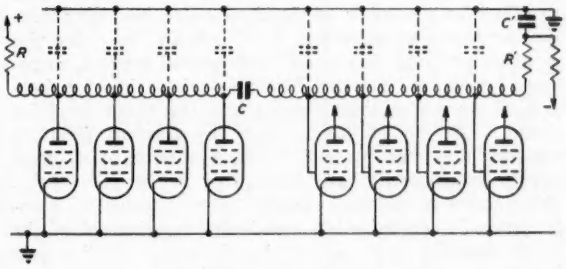
3. Oser, E. A., Endres, R. O., Moore, R. P. Transistor Oscillators. *RCA Rev. 13*, 369 (1952).

A Coupling Circuit for Distributed Amplifiers *

ALTHOUGH distributed amplifiers were first proposed by W. S. Percival as long ago as 1935 it is only recently that they have been put to any considerable use. These circuits, as is well known, possess the virtue of providing a high degree of amplification over very wide bandwidths. As an illustration of this valuable property they can for instance be used with effect over frequency ranges extending from a few cycles per second up to say 200Mc/s.

In applications of this kind there is inevitably some problem in how to couple one such amplifier to another; and it does not require much imagination to realize that in so extensive a range a coupling arranged to operate satisfactorily for the high frequencies of the band may well be inadequate for the lower frequencies; whereas another circuit which correctly transfers the lower frequencies may not transfer the high frequency components. Simple capacitance couplings tend to fail in both respects. As a result practical coupling circuits have been of rather special kind, and several proposals have been based on the well known constant resistance circuit. A circuit of a very much simpler form has, however, been put forward by Yu, Kallmann and Christaldi† and this is illustrated in the diagram. On the left of the diagram there is shown the anode line of one distributed amplifier, which is coupled to drive the grid line of a further distributed amplifier shown on the right of the diagram. As will be seen the two lines are connected simply by a capacitor C and as is normal the uncoupled end of the anode line is terminated in a resistor R equal to the characteristic impedance of the line. The remote end of the grid line is closed by a resistor R' connected in series with a capacitor C'. The junction of these two elements is connected through a leak resistor to a bias source so that the correct bias is applied to the control grids of the valves of the driven amplifier and this resistor is made of large value compared with that of the resistor R. Further, the characteristic impedances of the two lines are arranged to be equal and in order to give a flat frequency response over the whole range the magnitudes of the resistor R and R' are chosen to be identical; likewise the capacitances of the capacitors C and C'. For high frequencies the reactance of the capacitors C and C' is very small and the anode line is connected in effect directly to the following grid line, the latter line being terminated correctly in its characteristic impedance. For low frequencies such that the reactance of the capacitors C and C' cannot be regarded as negligible, the inductances of the lines act virtually as direct connexions and the shunt capacitances may be neglected. The arrangement then reduces to a driving amplifier of internal impedance equal to the characteristic impedance of the line in series with the reactance of the capacitor C, this amplifier operating into a load of identical impedance. The transfer between the two circuits is thus unity. In the cross-over range between the high and low frequency bands the response remains uniform.



Coupling of distributed amplifiers.

By an interesting departure which entails only a modification of circuit parameters, the arrangement may be made to function with a greater gain that is possible in the form just described. This follows from the fact that the total stray capacitance associated with the anodes of the valves driving the anode line tends in practice to be less than the total stray capacitances associated with the control grids of the control grid line. The anode line may therefore be operated with a higher characteristic impedance giving greater amplification. In these circumstances of course the simple choice of values advocated by Yu, Kallmann and Christaldi cannot be used but a flat response is obtained if the time-constant of the capacitor C and the resistor R is made equal to the time-constant of the capacitor C' and the resistor R'. It will be realized that operating the circuit with the two lines of unequal impedance must give rise to a reflexion at the higher frequencies from the input of the grid line back along the anode line. This reflexion, however, is of no consequence since it becomes absorbed by the terminating resistor of the anode line.

* *Communication from E.M.I. Ltd.*

† Yu, Y. P., Kallmann, H. E., Christaldi, P. S. Millimicrosecond Oscillography. *Electronics, 24*, 106 (July, 1951).

A Cascode Amplifier Degenerative Stabilizer

By V. H. Attree*, B.Sc.

A modified cascode amplifier has a gain of over a thousand times. A degenerative stabilizer using the cascode has a much better performance than a conventional stabilizer having a pentode shunt amplifier. The circuit is simple and does not require compensation from the unstabilized side.

THE performance of a degenerative stabilizer is largely dependent on the gain available in the shunt amplifier. For instance, the output impedance Z_o of such a stabilizer is given by the approximate expression $Z_o = 1/g_m\alpha$, where g_m is the mutual conductance of the series valve and α the effective shunt amplifier gain. In a typical circuit[1] using a pentode shunt amplifier $g_m = 5\text{mA/V}$ and $\alpha = 100$ giving an output impedance Z_o of 2Ω. This value of output impedance is about the best that can be achieved with a single pentode shunt amplifier. With stabilizers of this type a high gain cannot be obtained with the anode load of the shunt valve returned to the stabilized side of the supply, and it is usual to run the shunt valve from the unstabilized side. This gives rise to undesirable feedback at low frequencies and causes the effective gain to be much smaller, especially at frequencies around 10 to 15c/s, where the impedance of the unstabilized side is at a maximum. This reduction in gain increases the stabilizer output impedance at low frequencies; for instance, in the circuit previously mentioned[1] the impedance rises from 2Ω at 100c/s to a maximum of 30Ω at 12·5c/s. A not less important effect of running the shunt valve from the unstabilized side is to increase the effect of mains voltage changes on the output.

There are two main ways of overcoming the reduction in effective gain. The first is to provide a separate neon stabilizer for the anode of the shunt valve; this introduces another source of noise into the circuit and may give rise to striking-voltage difficulties. The second method, sometimes known as "forward feedback", is to inject a fraction of the unstabilized voltage into the shunt amplifier circuit. The use of compensation by forward feedback was first described by Miller[2] and a number of different circuit arrangements have been given in the literature[1-7]. The fraction of the unstabilized voltage required for compensation is approximately equal to the reciprocal of the shunt amplifier gain (i.e. $1/\alpha$). Unfortunately the gain is a function both of the frequency and the load current, so that exact compensation is only possible at one frequency (which can be d.c.) and at one load current. A practical difficulty with forward feedback is that the optimum setting for the feedback potentiometer can be found only by modulating at a low frequency either the load or the power supply voltage: adjusting the control for minimum hum at the output, as is the usual practice, does not necessarily give the correct setting.

A very effective way out of these difficulties is to use a modified cascode shunt amplifier. This will give a gain of over 1 000 and will run directly from the stabilized side of the supply. Thus, not only is the performance much better, but forward feedback is no longer necessary, which eliminates one variable control.

The cascode arrangement is no more complex than the pentode and, in fact, from the component point of view, the only difference is that a double-triode valve is required in place of the pentode, the number of resistors being the same.

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Cascode Amplifier

The basic cascode amplifier is shown in Fig. 1. The input signal is fed to V_1 grid and the output is taken from V_2 anode. The circuit was first given by Hunt and Hickman[8] and subsequently it has been discussed by a number of other writers [9-15]. The complete gain equation for the circuit is given below and for the present we will use the

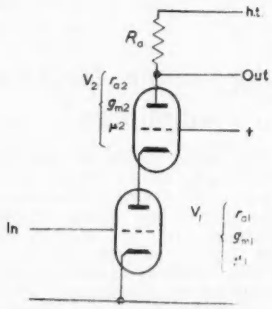


Fig. 1. Basic cascode circuit

approximation $A = g_{m_1}R_a$, where A is the gain, g_{m_1} the mutual conductance of V_1, and R_a the anode load. From this expression it would appear that the gain of the simple cascode would increase linearly with the value of the anode load. However, in a practical amplifier the supply voltage is fixed and an increase in the load results in a decrease in the anode current at which the cascode can be run. The reduced anode current results in a smaller value for the mutual conductance g_{m_1}, as the slope of a triode is a function of the anode current. This point is illustrated by some measurements on a 12AX7 valve given in Fig. 2. The measurements were taken by a bridge method with a very small grid signal (<1mV) and at an anode potential of 70V. Similar curves, but with somewhat lower values of g_m, are obtained with other double triodes, such as the 12AT7 and 12AU7, operating in the low-current region. Both scales are logarithmic and a linear relation between anode current and mutual conductance would be represented by a line of unit gradient. It will be seen that for a range of currents of 5 to 500μA the gradient is approximately unity and the relation may therefore be taken as being linear. Thus we may replace g_{m_1} by Ki_a, where K is a constant and i_a the anode current, and the simplified expression for the gain of the cascode becomes Ki_aR_a. When the cascode is used as a shunt amplifier in a voltage stabilizer the important property is the gain obtainable for a particular voltage drop across the anode load: on this

basis the cascode gain Ki_aR_a is independent of the load resistance.

The gain limitation due to the change of valve parameters with anode current may be overcome by running the lower valve V_1 at a much higher anode current than the upper valve V_2. In this way the mutual conductance g_{m_1} can be maintained at a high value irrespective of the value of R_a in V_2. The additional current for V_1 is obtained by a resistor connected between the h.t. line and V_1 anode. The impedance at the junction of V_1 anode and V_2 cathode is relatively low and is virtually unaffected by the added resistor.

The Modified Cascode

Although the very simple treatment given above leads to conclusions that are essentially correct, it is as well to examine the circuit in a little more detail in order to evaluate the magnitude of the approximations involved.

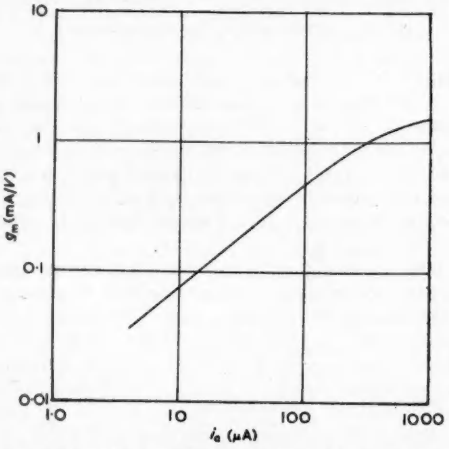


Fig. 2. Relation between mutual conductance and anode current for 12AX7 at $V_a = 70V$

The exact expression for the gain of the cascode in Fig. 1 is:

$$A = \frac{\mu_1(\mu_2 + 1)R_a}{R_a + r_{a_2} + r_{a_1}(\mu_2 + 1)} \quad \ldots\ldots\ldots\ldots (1)$$

for *equal* valves this reduces to:

$$A = \frac{\mu(\mu + 1)R_a}{R_a + r_a(\mu + 2)} \quad \ldots\ldots\ldots\ldots\ldots (2)$$

However, in the modified cascode r_{a_1} is *not* equal to r_{a_2} and it is necessary to proceed as follows: For a triode valve μ is substantially independent of anode current and both g_m and r_a are functions of current. The product $g_m r_a$, which is, of course, equal to μ, remains constant. The valves V_1 and V_2 are both halves of the same double triode, hence $\mu_1 = \mu_2$. Further, if we take a 12AX7 valve μ is 100 and we may write μ for $(\mu + 1)$ in equation (1) with no serious error. Hence equation (1) becomes

$$A \simeq \frac{\mu^2 R_a}{R_a + r_{a_2} + \mu r_{a_1}} \quad \ldots\ldots\ldots\ldots (3)$$

dividing by μr_{a_1}

$$A \simeq \frac{g_{m_1} R_a}{1 + (R_a + r_{a_2})/\mu r_{a_1}} \quad \ldots\ldots\ldots\ldots (4)$$

If the lower valve V_1 operates under nearly constant conditions with an anode current of 700μA its mutual conductance is 1·4mA/V (Fig. 2) and r_{a_1} is 70kΩ. The term μr_{a_1} in the denominator is therefore 7MΩ. Thus if the gain is to be given by the numerator of equation (4) then $(R_a + r_{a_2}) \ll 7M\Omega$. If R_a is 1MΩ and the anode potential drop is 20V then the anode current is 20μA giving $g_{m_2} =$ 0·1mA/V (Fig. 2) and $r_{a_2} = 1M\Omega$. Hence $(R_a + r_{a_2})$ is 2MΩ, and the actual gain is 20 per cent less than $g_{m_1}R_a$.

Application to a Degenerative Stabilizer

In a practical stabilizer circuit the gain is reduced by the effect of the reference neon in the cathode circuit of the lower valve. In order to measure the gain realized under working conditions the arrangement of Fig. 3 is used. The switch S_1 permits the 220kΩ resistor R_4 to be brought into circuit. The additional current supplied via R_4 to the lower valve is 670μA. The bias voltage V_B is adjusted to give the desired potential drop across R_a and gain measurements are made at a frequency of 500c/s. The curves of Fig. 4 are made for a fixed potential drop of 20V across the anode load. With S_1 open and for anode loads of 200kΩ to 4MΩ the gain remains very nearly constant at

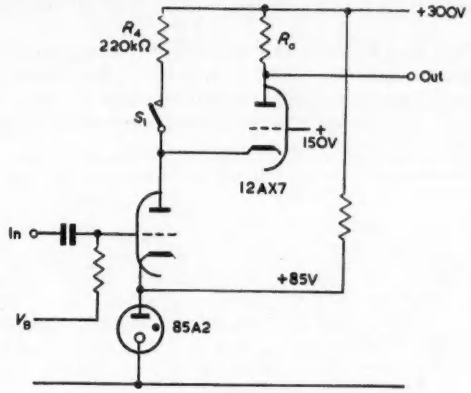


Fig. 3. Modified cascode circuit

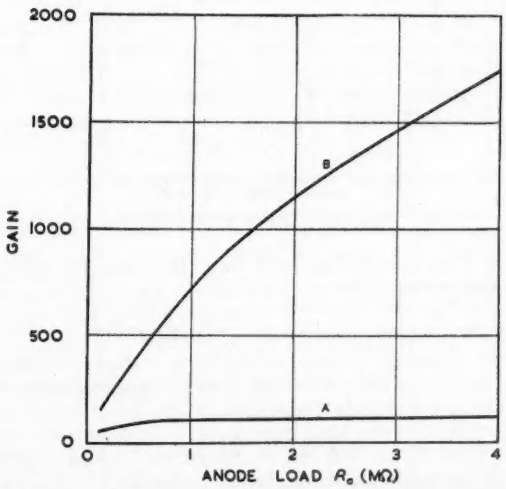


Fig. 4. Relation between anode load and gain of modified cascode with 20V d.c. drop on load

Curve A, S_1 *open*: *curve* B, S_1 *closed.*

about 100 times (curve A), and with S_1 closed the gain increases with load until at 4MΩ it is 1 700 times (curve B). The second set of curves, shown in Fig. 5, illustrate the relation between gain and potential drop across a fixed anode load of 2MΩ. With S_1 open (curve C) the gain increases linearly with potential drop, as expected from the simple theory, while with S_1 closed (curve D) the gain is 1 000 for a 10V p.d. improving to 1 500 at 100V p.d.

From these measurements it is evident that, even when taking the effect of the neon reference tube into account, the gain of the modified cascode will be at least 1 000 times for a potential drop of 10 to 100V across the load. This corresponds to anode currents of 5 to 50μA in the upper valve.

A high gain at low anode currents can also be obtained by the so-called "starvation" circuits[16,17], but these have less gain than the cascode and are reported to have poor stability[18]. Starvation circuits require much higher anode

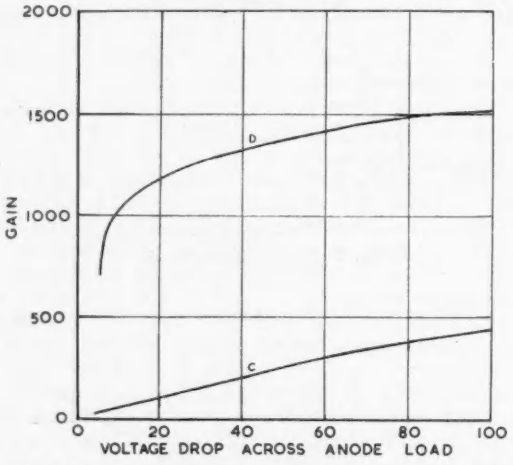


Fig. 5. Relation between voltage drop on anode load and gain of modified cascode with 2MΩ load

Curve C, S_1 open: curve D, S_1 closed.

loads than the cascode and have therefore an inferior frequency response.

Cascode-Amplifier Degenerative Stabilizer

The circuit of a complete stabilizer is shown in Fig. 6. The gain reduction due to the neon impedance is avoided at medium and high frequencies by the 0·1μF decoupling capacitor C_1. The 100Ω resistor R_6 is necessary to ensure that there is no risk of relaxation oscillations between the capacitor and possible negative resistance of the neon tube. Unfortunately the added resistance increases the impedance in the cathode circuit of the lower triode at very low frequencies and d.c. The capacitor C_1 also helps to reduce the amount of noise from the neon tube. The cascode anode load R_5 is 2·2MΩ so that the gain characteristics are essentially as given by curve D in Fig. 5. The total capacitance at the grid of the 12E1 is 32pF and the frequency response of the cascode is 3dB down at 2·5kc/s. A low output impedance at higher frequencies is maintained by the large capacitor C_3 shunted across the output. Because of the high amplifier gain the cascode grid is susceptible to hum pick-up. Hum troubles are largely avoided by making the impedance of the voltage divider $R_{7\text{-}10}$ fairly low and by locating the control potentiometer R_9 close to the

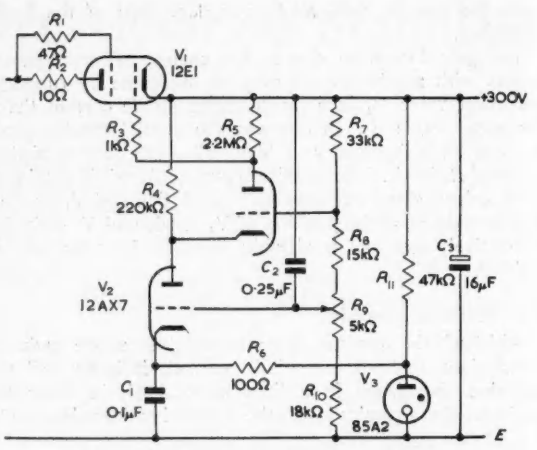
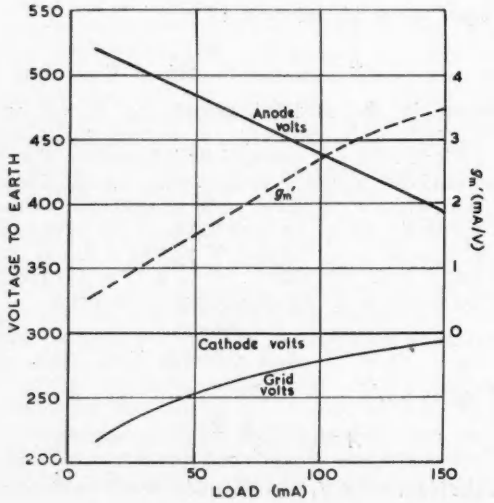


Fig. 6. Cascode-amplifier degenerative stabilizer

valve grid pin. The 0·25μF by-pass capacitor improves the action of the stabilizer by eliminating the attenuation of the voltage divider at medium and high frequencies. With careful layout the total hum and noise level at the output is 100 to 200μV r.m.s.; the exact value depends mainly on stray voltages induced from heater and mains wiring rather than on the hum level at the unstabilized side which is 2 to 5V.

As in the case of the shunt stage the valve parameters of the series valve change very considerably over the working range. The actual voltages on the 12E1 series valve V_1 are shown in Fig. 7. The voltage at the anode falls from 525V at 10mA load to 390V at 150mA and the corresponding grid voltage change is from 210V to 295V corresponding to a potential drop across the anode load of the cascode of 90V down to 5V. These are typical values for a stabilizer, although with a smaller series valve, such as the EL81, the grid base will be shorter. The effective value of the mutual conductance g_m' is found by differentiating the grid voltage curve with respect to load current. The value of g_m' changes from 0·5mA/V at 10mA load to 3·5mA/V at 150mA load.

Fig. 7. Characteristics of 12E1 series valve in Fig. 6



The large range of effective slope shows why forward feedback in a conventional stabilizer can be made to give exact compensation only over a narrow range of load current.

The output impedance of the stabilizer has been measured at several values of load current and for the frequency range 0 to 50kc/s. The impedance is in general about 0·2Ω increasing to 0·5Ω at d.c. where the capacitors C_1 and C_2 are ineffective.

The impedance rises at frequencies around 30kc/s and as the reasons for this are somewhat complex the matter is discussed in the next paragraph.

High-frequency Performance of Cascode Stabilizer

In degenerative stabilizers having a large shunt amplifier gain high-frequency instability troubles are often encountered. The difficulty arises because there is more than one effective time-constant controlling the rate of gain cut-off at high frequency. In the case of the cascode the high-frequency cut-off is dominated by the time-constant at the grid of the 12E1 series valve and oscillation troubles are absent. However, there is sufficient phase-change elsewhere in the circuit to cause a rise in the output impedance at a frequency of 30 to 50kc/s. The magnitude of this impedance rise may be reduced either by a phase-advance network to the cascode grid or by introducing a loss component in the output capacitor (C_3 in Fig. 6). The first method has the disadvantage that it entails a reduction in the gain at low frequencies and increases the danger of hum pick-up on the grid. The second method is much more convenient as the unwanted rise in output impedance can be almost completely suppressed by including a resistance of the order of 1Ω in series with the output capacitor.

It has been found that the necessary component is already present in electrolytic capacitors. The loss resistance of a number of different types of 16μF electrolytic capacitors has been determined on a Q bridge. The measurements were made at 50kc/s with an accuracy of about 0·1Ω. In every case the loss is between 0·7 and 1·5Ω and magnitude of the rise in output impedance, obtained with the capacitor on the stabilizer output, does not exceed 1·7Ω.

Balanced Cascode Circuit

One of the objections to the circuit of Fig. 6 is that heater voltage changes in the 12AX7, V_2, alter the contact potential in the lower valve of the cascode and hence cause a change in the output voltage. For a ±10 per cent change in the mains supply the output alters by ∓0·4V which corresponds to a change in contact potential of 110mV at the cascode grid. The difficulty may be overcome by using the circuit of Fig. 8. The neon potential is smoothed by the long time-constant filter R_{12} and C_1 and appears on the grid of V_{3b}, while the voltage divider R_{7-10} feeds the grid of V_{3a}. In this way variations in contact potential are balanced out in the long-tailed pair V_{3a}, V_{3b}. The upper valve of the cascode is V_{2b} and the triode section V_{2a} is used as a cathode-follower to drive the grid of the series valve. This improves the frequency response and is particularly useful when two or more series valves are used in parallel connexion in order to increase the available load current. The anode supply for the cathode-follower is taken from the unstabilized side of the supply; voltage variations at this point have negligible effect on the performance as the gain up to the cathode-follower grid is very high—of the order of 1 000 times.

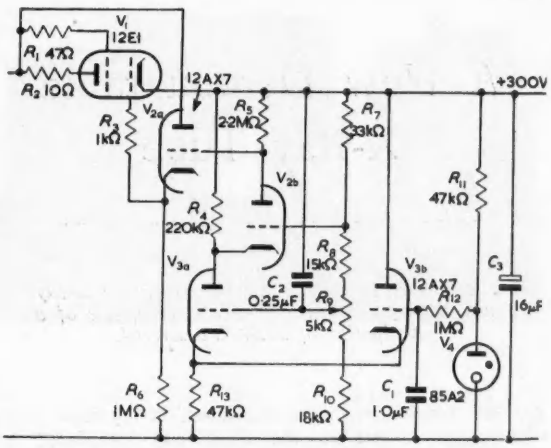


Fig. 8. Degenerative stabilizer with balanced cascode amplifier

With the balanced circuit a ±10 per cent change in the mains supply alters the h.t. line by ±70mV; of this output change ±30mV is due to the change in the voltage at the anode of the series valve and ±40mV is due to residual unbalance in the long-tailed pair V_{3a}, V_{3b}. Contact potential variations in V_{2a}, V_{2b} and the series valve V_1 have practically no effect.

Conclusion

In spite of the high gain the cascode presents no special difficulties of layout or stability and, at the time of writing some twelve power units have been constructed in this laboratory, mostly with the circuit of Fig. 6. These units all had hum levels of better than 500μV over the full load current range, and output impedances of about 0·2Ω at 500c/s.

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A New Demountable X-Ray Tube

By J. A. Darbyshire*, M.Sc., Ph.D., F.Inst.P.

The construction of a new demountable X-ray tube having a water cooled target capable of a dissipation of 500W is described.

SOME time ago a small sealed-off X-ray tube commercially known as the B100 was introduced by Ferranti Ltd.

This tube is shown in Fig. 1 and its electrical characteristics are as follows:

Filament voltage	2·5V
Filament current	5·5A
Target voltage (max)	40kV
Screen voltage	0 to 1·4kV
Spot size (approx.)	
(at 40kV and 100μA)	0·6mm
Max. target dissipation (continuous)	25W
Max. target dissipation (for 20 seconds)	500W

In response to requests for a tube of higher power the demountable type of X-ray tube shown in Fig. 2 has been developed recently.

This tube is designed so that it can be very easily dismantled and it is possible to clean or renew the target and fit a new filament and window in a very short time.

The main constructional features are as follows:

The end plates are made of brass and the vacuum joints between the end plates and the main glass of the tube are made by means of "O" rings.

These "O" rings are compressed between the two-component flanges which comprise the end plates of the system.

A similar technique is used to attach the window to the side tube. This window is made of polythene and is therefore very transparent to low voltage X-rays. A window of beryllium or aluminium or any other material could easily be fitted if desired.

The filament is constructed from tungsten wire and it is surrounded by a shield which can be used as a modulating electrode, and to some extent, as a focusing electrode. The target is water cooled and is capable of a dissipation of 500W.

For X-ray diffraction the target is designed to be end-on to the beam and the X-ray output can be taken from the window on the side tube.

If required, this diffraction tube can be provided with two windows, one on either side of the tube. For radiographic work the target is inclined at an angle of 67° to the beam so that a large uniform field of radiation is available.

The target is usually made of copper, but the end plate can be removed very easily and a target of another material such as nickel, cobalt or chromium can be inserted when it is desirable to use characteristic radiation of different wavelengths.

The tube is evacuated by means of any conventional high vacuum system. For example, a rotary oil pump type 1S50

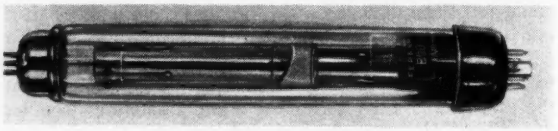


Fig. 1. The B100 X-ray tube

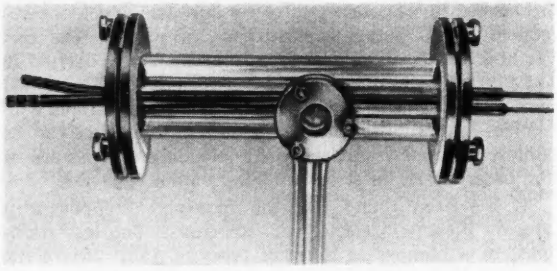


Fig. 2. The higher power sealed off X-ray tube

followed by a silicone diffusion pump of type 102 would be quite satisfactory.

The tube can be operated at any anode voltage up to 45kV and at any beam current such that the target dissipation of 500W is not exceeded. The beam current remains very steady during the operation of the tube when it is even as high as 15mA.

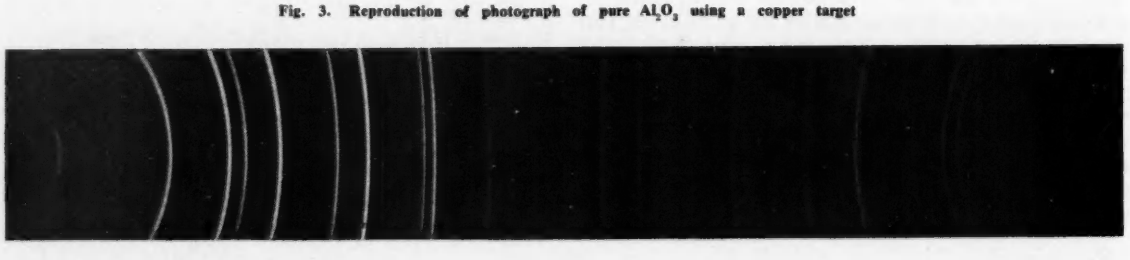
It has been found that very satisfactory X-ray photographs can be obtained when the target voltage is no higher than 25kV.

Fig. 3 is an illustration of a photograph of pure Al_2O_3 taken using a copper target. The tube in this instance was operated from a half-wave rectified supply of 25kV at a beam current of 15mA and the exposure was three hours.

These X-ray tubes have been developed in the Physical Laboratory at Moston by Mr. R. D. Phillips and Mr. D. M. Taylor and Mr. E. Thomas.

* *Ferranti, Ltd.*

Fig. 3. Reproduction of photograph of pure Al_2O_3 using a copper target

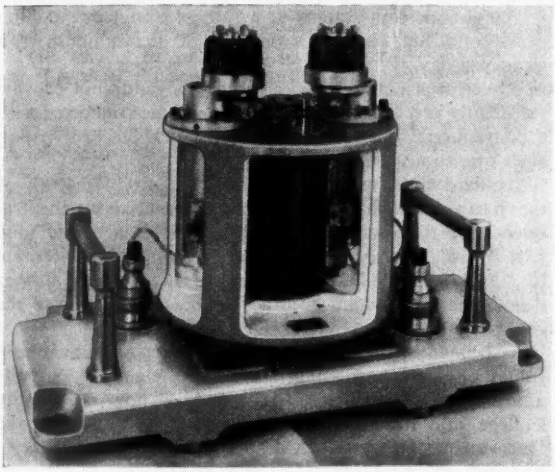


DEUCE

(A New Digital Computor)

THE English Electric Company have now developed a new digital electronic computing machine which is in commercial production.

This machine is the Digital Electronic Universal Calculating Engine (DEUCE). It is the outcome of years of intensive development of ideas first put forward shortly after the war at the National Physical Laboratory at Teddington. Sir George Nelson, Director of the English Electric Company, was approached at that time by Sir Charles Darwin of the N.P.L. with a request that the English Electric Company should assist the scientists at N.P.L. with the development of an Automatic Computing Engine, a machine of vast potential whose logical

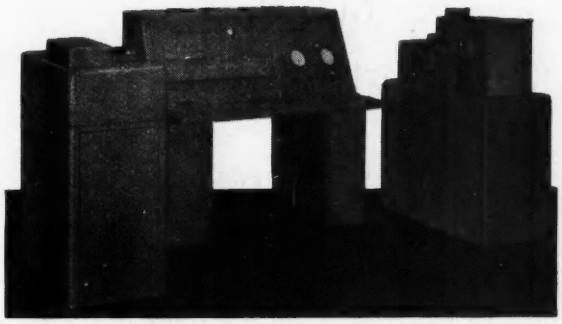


The magnetic recording drum

design had already been worked out at N.P.L. The company provided a team of engineers and craftsmen to work at Teddington and as a result a Pilot Model ACE was brought into successful operation in the Mathematics Division at N.P.L. in February 1952. This pilot model proved to be an outstanding success in solving problems for many branches of Government and industry. The experience gained with this early machine was of great help in determining the next stages of development. The English Electric Company decided to produce a fully engineered version of this machine embodying all the improvements which were suggested by the extensive operational experience at the N.P.L.

In the DEUCE, numbers and instructions are represented by sequences of pulses at intervals of 1 microsecond. A train (or " word ") of 32 such pulses is used to represent either a number (equivalent to 9 decimal digits with sign) or an instruction. Two forms of storage are provided. The first is intimately associated with the computing circuits and includes 12 mercury delay lines each storing 32 words together with 10 shorter lines of various lengths which are used as accumulating registers, etc. The second store of large capacity (8 192 words —or more than a quarter of a million digits) is provided by a magnetic recording drum. Information can be written on or read from 256 tracks by means of two sets of 16 heads, either of which can be moved into any of 16 positions by a high speed shifting mechanism giving access to any track in 25 milliseconds.

Input and output of information is on 80 column punched



The control desk and input and output mechanisms

cards of standard type. Use of a card punch instead of a printer on the output enables the maximum speed of the computor to be utilized; subsequent sorting and printing can then be carried out on standard machinery without occupying valuable computor time.

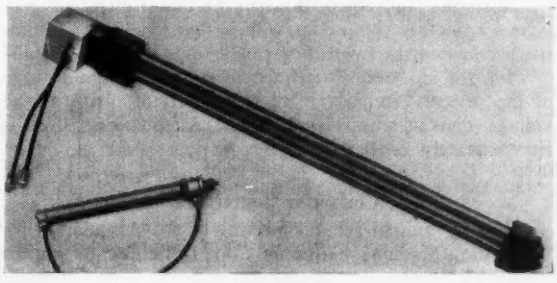
Each input card can carry 12 instructions or up to 32 decimal digits. The latter can consist, for example, of 3 9-digit numbers (each with sign) or several smaller numbers. Input of information in sterling or other non-decimal form is also possible. The computor can convert these numbers into binary form and send them to its storage system when cards are being read at the maximum speed of 200 per minute. The reverse process is carried out at the output, the speed in this case being 100 cards per minute, corresponding to about 50 decimal digits per second.

The physical form of the machine demonstrates its smallness compared with other machines of its scope and speed of operation. Although this overall size is conveniently small, this has not been achieved by close packing of components. A generous amount of space has been used and the components are easily accessible for maintenance and fault tracing. The main electronic units and the magnetic store are housed in nine vertical cubicles each containing about eight chassis of convenient size; together with the control desk it occupies a floor area of 14ft by 4ft 6in. Access is by doors to the components on one side of the chassis and by a central corridor to the valves which are all on the inward facing side of each chassis. The total number of valves used is about 1 300, all of standard miniature types and universally available. The mercury delay lines (other than short lines of one, two or four word lengths each) and contained in a thermostatically controlled drum, 3ft in diameter and 3ft 6in high, located a convenient distance away from the main electronic units.

A computing centre has already been set up in the Nelson Research Laboratories of the English Electric Company at Stafford and a further centre will shortly be established in London. A DEUCE computor will be permanently located at each of these centres and a team of mathematicians and operators will be available to offer a full computing service to organizations not requiring a machine for their own full time use.

A training service will be available based on the two computing centres for initiating scientists, mathematicians and machine operators in the actual use of machines supplied to their organization.

The mercury delay lines



Notes from North America

U.S. Defence Contracts

New regulations, which will make it easier for overseas countries to compete for U.S. Defence Department contracts, have been announced by the Secretary for Defence, Mr. Charles Wilson.

Under the so-called "Buy American Act", passed by Congress during the Depression, U.S. concerns were awarded the contracts even if their bids were as high as 25 per cent above foreign offers. Under the new order, dated February 21, foreign bidders will now be awarded contracts if the lowest acceptable foreign bid is 6 per cent or more below the lowest acceptable American bid.

Another easing of restrictions on foreign firms is contained in a re-definition of "foreign goods". Previously raw materials or manufactured items have been considered foreign goods if 25 per cent or more of the cost of materials went to foreign suppliers. Under the new regulations goods will be considered foreign only if 50 per cent or more of the cost of materials go to non-American sources of supply.

The new regulations continue to give the Secretary of Defence authority to refuse a contract to a foreign bidder if it would be detrimental to the national security or the national interest.

Two new exceptions have been added, based on provisions of the Presidential order issued last December. In certain cases the Secretary of Defence may favour a domestic bidder if it is necessary to do so in order to give a fair proportion of defence contracts to small business concerns, or to place defence contracts in areas of the United States where there is serious unemployment.

Dielectric Potentiometer

A new voltage divider, which it is claimed is free from phase and frequency distortion over a range of frequencies from 20c/s to 10Mc/s, is announced by the Technology Instrument Corporation of Acton, Mass.

The dielectric potentiometer is a three-terminal network employing a liquid as the variable element. The effective resistance-capacitance shunt and series elements of this network result from the inherent resistivity and dielectric constant of a lossy liquid dielectric immersing the terminal electrode structures. The output electrode is movable with respect to the input electrode. Since the resistance and capacitance components vary in exactly inverse manner with movement of the output electrode, a constant *RC* product is maintained in each of the ratio arms.

The stopless movement through the liquid dielectric provides a smoothly continuous voltage division. The constant *RC* product of the two ratio arms assures the same voltage division for any and all frequencies within the band range of the device. Similarly there is no shift of phase as the voltage division ratio is changed. Attenuation range is approximately 25dB.

Computor Conference

The 1955 annual general meeting of the Association for Computing Machinery—the only one to be held during the year—will take place at the Moore School of Electrical Engineering, University of Pennsylvania, September 14-16, inclusive. As in the past, this meeting is intended to serve as a place for the reporting of new ideas and developments in the applications of computing machinery.

Cesium Atomic Frequency Standard

A new atomic frequency standard has recently been developed by Dr. J. R Zacharias, of the Laboratory for Nuclear Science at the M.I.T.

The atomic clock built primarily for research is expected to have practical uses such as more accurate methods of navigation and studies in astronomy, geophysics and radio communications.

Time keeping in the device is controlled by the oscillation of electrons in the cesium atom.

One one-hundredth of a gram of cesium is enclosed in a metal crucible. Under heat, about that of boiling water, the cesium shoots a stream of atoms through a hole in the crucible. The atoms strike a detector screen and their frequency is reported through complex apparatus.

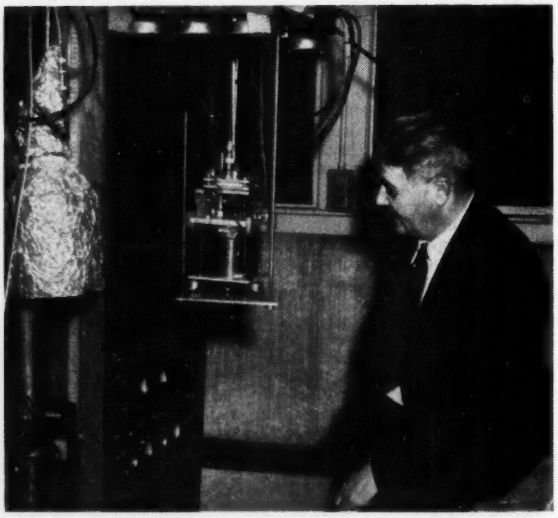
The cesium emits atoms at a rate of about one million per second, but the loss is only about one-millionth of a gram per day.

While for scientific work, clock hands would not provide sufficiently precise timing, the device can be connected with a conventional but finely calibrated clock face for use in such operations as navigation.

Standard time, with one second equal to 1/86 400th of the mean solar day and generally measured by the frequency of the oscillations of a crystal, is accurate to 1 part in 10^9. The Atomic Frequency Standard is accurate to 1 part in 10^{10}. Dr. Zacharias expects, through further development, to obtain accuracy of one part in ten to the twelfth power.

Associated with Dr. Zacharias in the work have been James G. Yates, an English electrical engineer who was a visiting professor at M.I.T. and is now at Trinity College, and Robert D. Haun, a research assistant in the Department of Physics at M.I.T.

Dr. Zacharias with the cesium clock



Short News Items

The Television Society has awarded the following Premiums, of £5 each, for outstanding papers read before the London meetings in 1954. The *Electronic Engineering* Premium to Dr. G. N. Patchett, of Bradford Technical College, for his paper on "Problems of Interlacing". The Mullard Premium to Messrs. G. B. Townsend, E. Ribchester, and D. Bauer (G.E.C.) for their paper on "An Investigation of the 625 line C.C.I.R. System". The E.M.I. Premium to Messrs. R. J. Boddy and C. D. Gardner (E.M.I. Research Department) for their paper on "An Industrial Television Channel" A special Premium for the Society to Mr. G. G. Gouriet (BBC Research Department) for his paper on "Colour Television".

The Annual Dinner of The Institution of Electrical Engineers was held on Thursday, 24 February, when the President, Mr. J. Eccles, was in the Chair. The principal guest was The Rt. Hon. Sir Raymond Evershed, Master of the Rolls, who proposed the toast of "The Institution", to which the President replied. The toast of "Our Guests" was proposed by Mr. Harold Bishop, immediate past-president, and the reply was given by The Rt. Hon. Lord Citrine, Chairman, British Electricity Authority.

The Tenth Annual Exhibition organized by the Northern Division of the Institution of Electronics will be held at the College of Technology, Sackville Street, Manchester, from 14-20 July. The sessions will be from 2 p.m. to 10 p.m. on 14 July, 10 a.m. to 10 p.m. on 15, 18, 19 and 20 July, and 10 a.m. to 6 p.m. on 16 July. The exhibition, which is organized for its educational value, will consist of a Manufacturers' Section, a Scientific and Industrial Research Section, and will include a programme of lectures and film shows on subjects allied to electronics. Lecture and film show programmes (price 4½d. post free) will be available in June. Advance catalogues (price 2s. post free) will be on sale early in July. Admission to the exhibition, lectures and film shows will be by tickets obtainable, free of charge, from the Honorary Exhibition Organizing Secretary, Mr. W. Birtwistle, 78 Shaw Road, Rochdale, Lancs. A stamped addressed envelope should be enclosed.

Rocke International Ltd are organizing jointly with Bruel & Kjaer Laboratories Ltd a private exhibition of the latest American and Continental electronic instruments and components, to be held in London from 25 April to 6 May at 59 Union Street, London, S.E.1, between 9 a.m. and 7.30 p.m. Tickets are available on application to the address mentioned.

A Conference on the production and utilization of electromagnetically enriched isotopes will be held at the Atomic Energy Research Establishment, Harwell, from 13-16 September this year. Several leading members of the team responsible for the work on stable isotopes at Oak Ridge, U.S.A., are attending, while provisional acceptances have also been received from leaders of the separator groups in France, Holland and Denmark. Although a detailed programme has not yet been prepared, sessions will be included on design and operation of large mass separators; ion source and collector problems especially with high beam current; separation of radioactive materials; chemical aspects of the production work; preparation of isotopic targets; developments in stable isotopes mass-analysis; utilization of electromagnetically enriched isotopes. Those wishing to attend should write immediately to Dr. M. L. Smith, A.E.R.E. Harwell, Didcot, Berks, indicating also whether they will make a written contribution. Abstracts of papers must be submitted before 30 April and complete manuscripts before 30 June.

La Société des Editions Radio, 9 Rue Jacob, Paris, have produced a new bimonthly journal called *Electronique Industrielle.* It is hoped that this journal will provide useful information for those interested in the electronics field. The price of this new journal is 300 Francs an issue.

The Scientific Advisory Board of the journal *Research* has decided for the third successive year to organize, with the co-operation of *The Sunday Times,* a "Science in Industry" essay competition. The purpose of this competition is to encourage scientists to take greater interest in the problem of presenting the results of scientific research work to people less highly qualified than themselves.

The Electrical Industries Benevolent Association are celebrating their Golden Jubilee by a luncheon in the Grand Hall at the Connaught Rooms on Tuesday, 19 April. The principal guest is Sir John Maud, K.C.B., C.B.E., Permanent Secretary to the Ministry of Fuel and Power.

Marconi's Wireless Telegraph Co Ltd announce that Associated-Rediffusion Ltd, through their technical advisers, Central Rediffusion Services Ltd, have placed a major contract for the provision and planning of most of their studio and outside broadcast equipment with Marconi's. The initial order includes the complete installations for three three-camera studios, one two-camera studio and two complete three-camera television outside broadcast vehicles. In addition, Marconi's are to supply one set of master control switching and central apparatus equipment, and the equipment for a further television outside broadcast unit, less vehicle. This large order is being completed so that Associated-Rediffusion can be on the air by 1 September.

Work has already been started by Marconi's on the temporary transmitter at Croydon, following upon the ITA announcement of their plans for a television station in the London area.

The Central Office of Information have made an announcement concerning a new free loan section of their film library. The following films are among those available. "The Electron Microscope"; "Electric Induction Heating"; "Ammeters and Voltmeters"; "Capacitors"; "Effects of Inductors and Capacitors on A.C. and Power Factor". Other titles will be added to the new free section in the near future.

The Imperial College of Science and Technology are holding a course of eight lectures by Professor W. D. Wright on "The Science of Colour applied to Colour Television". They will be held on Tuesdays and Thursdays at 4.30 p.m. commencing on Tuesday, 26 April. Application for admission should be made to the Registrar of Imperial College, Prince Consort Road, London, S.W.7. The fee for the course is £2 2s.

The Press Office of the United Kingdom Atomic Energy Authority has moved from Bedford Chambers, Covent Garden. The address of the Chief Press Officer, Mr. Stanley White, is now St. Giles Court, 1-13 St. Giles High Street, London, W.C.2.

Addendum. In connexion with the article "Submerged Repeaters for the Aberdeen-Bergen North Sea Cable", which appeared on p. 126 of the March issue, Submarine Cables Ltd have now submitted the following clarification. The repeaters in question were built and tested in the factory of Standard Telephones & Cables Ltd at North Woolwich, as stated, but they were provided with, and sealed into, pressure-resisting housings at the Ocean Works (Erith) of Submarine Cables Ltd. The sealed housings were there subjected to a test pressure of 1½ tons/in², which in view of the relatively shallow water in which they were to be laid was amply sufficient. Test facilities at Ocean Works include for the testing up to 4 tons/in² of repeater housings for submersion in ocean depths of the order of 2 000 fathoms.

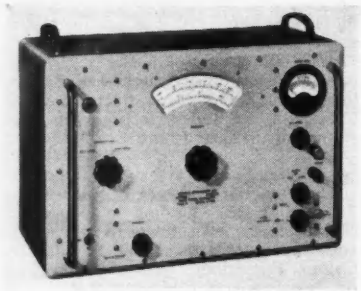
R.E.C.M.F. EXHIBITION PREVIEW

A description, compiled from information supplied by the manufacturers, of selected exhibits to be shown at the Exhibition of the Radio and Electronic Component Manufacturers Federation, in Grand Hall, Grosvenor House, Park Lane, London, W.1., from 19 to 21 April.

(Figures in parenthesis refer to Stand Numbers).

Advance (30)

INCLUDED among a number of new productions on this stand will be the video signal generator type R1 (*illustrated below*). A feature of this generator, which employs an *RC* phase shift oscillator, is the wide frequency range covered in each of the two ranges, which are 30c/s to 3Mc/s and 3Mc/s to 10Mc/s, with a generous overlap between ranges. The effective dial length is 27in. Output is from a cathode-follower at an impedance of 75Ω via a three stage decade attenuator, maximum e.m.f. being IV. A high



impedance output (max. 10V) is also provided. The output is monitored by a crystal voltmeter.

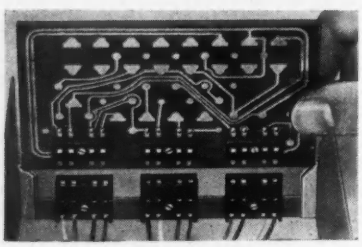
Advance Components Ltd.,
Marlowe Road,
Walthamstow,
London, E.17.

Belling-Lee (16)

A NUMBER of new components will be shown on this stand, including aerials and aerial adaptors for Band 3 television, and instrument fuse-links (type L.1 055) manufactured by a new technique which bonds caps, glass and filament into one unit.

In addition a range of plugs and sockets (*illustrated below*) designed specifically for use with printed circuits, will be shown.

Belling & Lee Ltd.,
Great Cambridge Road,
Enfield, Middlesex.



B.I.C.C. (57)

IN addition to their normal ranges of cables, winding wires and couplers, B.I.C.C. will, this year, be showing a new range of television downlead cables insulated with cellular polythene.

British Insulated Callenders Cables Ltd.,
21 Bloomsbury Street,
London, W.C.1.

Bulgin (21)

THE vast range of Bulgin switches, plugs and sockets, lampholders, etc., has been still further increased and a number of new items will be shown.

The range of fittings for Acro micro-sensitive switches has been increased and types operating from pressures as low as 0·75oz and 0·01in movement are available. A new sub-miniature type will also be shown.

A. F. Bulgin & Co. Ltd.,
Bye Pass Road,
Barking, Essex.

Dawe Instruments (73)

ONE of the latest instruments on display on this stand will be the type 1107 Visigauge.

The Visigauge measures thickness from one side by determining the fundamental natural frequency of vibration in the thickness direction.

The natural frequency of thickness vibration is essentially independent of the other physical dimensions of the material.

NOTE.—As this issue will have gone to press almost a month before the opening of the exhibition, this preview is necessarily incomplete as a number of exhibitors have not yet finalized or released details of their exhibits.

A vibrating quartz crystal is placed in contact with one side of the material under test so that an ultrasonic wave is transmitted into the material. This wave travels in a narrow beam through the material and is reflected by the opposite surface. At certain frequencies, when the transmitted and reflected waves are in phase, there will be a relatively large increase in the amplitude of the wave in the material. This is a resonance condition occurring at the fundamental frequency and harmonics of the fundamental frequency.

The fundamental resonance frequency is inversely proportional to twice the thickness and directly proportional to the velocity of sound in the material. The velocity of sound is known for most materials and thus the thickness can be determined.

The thickness is indicated on a c.r.t., a calibrated scale for a given material being fitted in front of the tube. Five crystals cover the range of 0·015in to 0·3in for steel.

Dawe Instruments Ltd.,
99 Uxbridge Road,
London, W.5.

De La Rue (83)

INCLUDED in this company's exhibits will be a new grade of laminate known as Delaron Copper Clad.

The laminate, faced with copper foil, is now being used in the manufacture of printed circuits, with the circuit drawing transferred to the copper clad by litho, silk screen or photo-engraving techniques. Surplus copper foil, not protected by the acid-resisting inks used in the printing of the circuit, is then etched away, leaving a permanent electrical conductor serving as a connecting medium for many kinds of electrical components.

De La Rue produce three grades, the base laminates conforming to R.C.S.1 000 and B.S.S.1 137 specifications.

Thomas De La Rue & Co. Ltd.,
Imperial House,
84/6 Regent Street,
London, W.1.

Electrothermal Engineering (120)

THE Precistor range of wire wound high stability resistors has been extended to include resistance values up to 3MΩ. These are available, tapped or untapped, in any value as required. In addition to the high stability types a range of standard wire wound resistors has been introduced.

Of interest too is the Electrothermal Valve Retainer and Valve Data Manual, which details the correct types of retainer for any given valve.

Electrothermal Engineering Ltd.,
270 Neville Road,
London, E.17.

Enthoven (58)

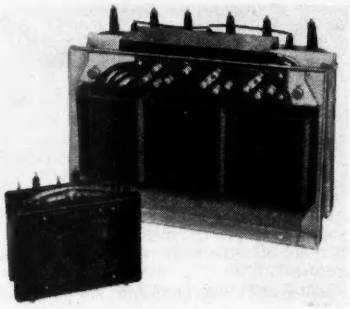
NEW developments shown by Enthoven this year will be aluminium cored solder and dip soldering materials for printed circuit techniques.

It is claimed that the aluminium cored solder solves all problems in the tinning and soldering of light-gauge aluminium and aluminium alloys and enables copper wire to be joined with ease to aluminium surfaces.

Enthoven Solders Ltd.,
Enthoven House,
89 Upper Thames Street,
London, E.C.4.

Ferranti (44)

A NEW range of "Pentland" series resin cast 3-phase transformers (*illustrated below*) will be shown in addition to a full display of single-phase transformers, chokes and delay networks employing the resin cast technique. T.R. cells, which will be displayed include 3cm tuneable and broad band types together with a range of



10cm cells. An integrated microwave test bench designed for use in the 3cm band and incorporating the milled block technique of waveguide manufacture will be shown.

There will be a display of 2in, 2¾in and 3½in hermetically sealed instruments for the latest Service requirements. Included in these are instruments with American fixing centres providing interchangeability on N.A.T.O. equipment. Moving iron voltmeters with a frequency range of 50 to 2 000c/s will be shown.

Ferranti Ltd.,
Hollingwood,
Lancashire.

G.E.C. (135)

A WIDE range of new valves will be shown. Included among these is the Osram DA42, which is designed for use in pairs in public address amplifiers where output powers of 175W are required. A triode with an indirectly heated cathode, it can be used to replace the DA41 in existing equipment.

The heater voltage and current are 7·5V and 1·2A respectively. In a typical push-pull class-B amplifier, the anode voltage for the pair is 1 000V for normal speech and music. Continuous 100 per cent tone modulation will, however, result in excessive dissipation and for such applications the normal anode-anode load of 10kΩ should be increased to 12kΩ, which will cause a reduction of the power output to 150W.

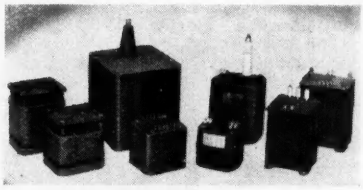
Other new valves displayed include : the KT55 power tetrode which is designed for use as an audio frequency amplifier ; the DH719 triple diode triode and the B719 r.f. double triode, for use in f.m.-a.m. radio receivers ; the X719 triode heptode, which is primarily a frequency changer ; the W719, a remote cut-off, high slope r.f. pentode for use in f.m. radio receivers ; the HN309 triode pentode which has a high μ triode ; and the WD709 double diode pentode, the pentode section being suitable for use as an r.f. or i.f. amplifier.

Also introduced are three new semi-conductor devices. These are a medium power germanium pn junction rectifier, a high frequency point contact transistor and a junction transistor.

The General Electric Co. Ltd.,
Magnet House,
Kingsway,
London, W.C.2.

Gresham Transformers (70)

FOR some time Gresham Transformers Ltd. have held Approval Certificates for C-core hermetically sealed types and for



open types with standard laminations. Now their C-core open type has been granted Type Approval to Humidity Class H.1 and their "Leocast" (resin moulded) type with standard laminations has been granted limited approval to humidity class H.1.

The Leocast range offers particular advantages in physical and dielectric strength combined with outstanding resistance to humidity and temperature variation.

Illustrated above are, from left to right, in pairs, C-core open type, Leocast (resin moulded) with standard laminations, hermetically sealed C-core, open type with standard laminations.

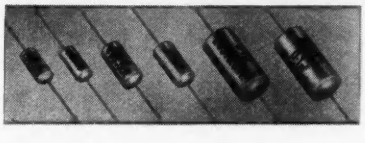
Gresham Transformers Ltd.,
Twickenham Road,
Hanworth, Middx.

Hunts (23)

INCLUDED in the new types of capacitors to be shown is the Midget Supermoldseal type W96 (*illustrated below*). These metallized paper capacitors are enclosed in a new cast resin housing which is proof against humidity, mechanical shock and heat contact. They are available in a wide range of values up to 0·1μF.

Also to be shown are ranges of capacitors developed for use in all types of printed circuit.

A. H. Hunt (Capacitors) Ltd.,
Bendon Valley, Garratt Lane,
London, S.W.18.



Imhof (25)

A WIDE range of cabinets, racks (including totally enclosed types), control consoles and fittings, will be shown.

The control console can be supplied in either double or single pedestal (the single with tubular leg, either left- or right-hand). The pedestal frames are drilled front and back to take standard 19in panels and an inset frame is provided mounted either 19in from the back or front so that standard chassis runners and telescopic runners may be fitted. Consoles are available with two types of superstructure, consisting of a full length 3-bank unit taking either 10½in or 15¾in standard 19in rack panels inclined at 13° to the vertical. The console top is of grey linette formica.

Alfred Imhof Ltd.,
112 New Oxford Street,
London, W.C.1.

London Electric Wire Company (61)

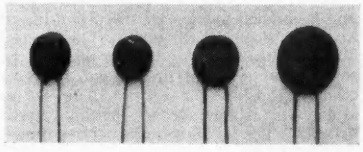
THE ever extending range of insulated electrical winding wires now includes self-fluxing enamelled wires including "Lewcosol" and "Lewtinex." Lewcosol wire can be soldered rapidly with an iron without prior removal of the enamel film. It has good all-round properties, complying in most respects with British Standard 184. Lewtinex is a modified type of Lewmex, which retains all the excellent properties of Lewmex and, in addition, can be dip-tinned in molten solder at 475°C.

Heat-resisting insulated wire including types covered with p.t.f.e. and terylene, will be shown.

The London Electric Wire Co. & Smiths Ltd.,
24 Queen Anne's Gate,
London, S.W.1.

London Electrical Manufacturing Co. (36)

A WIDE range of silvered mica and silvered ceramic capacitors will be shown.



The range of F.E.C. silvered ceramic capacitors has been extended and includes tubular types from 1pF to 0·01μF, and disk types (*illustrated above*) from 470pF to 0·01μF, and the new lead through pattern which is designed to have a small physical size, exceptionally low inductance and low initial cost.

London Electrical Manufacturing Co. Ltd.,
Beavor Lane,
Hammersmith,
London, W.6.

Marconi Instruments (103)

THIS company will be exhibiting a number of telecommunications test instruments including several new models.

In the field of frequency measurement, the company is showing the e.h.f. wavemeter TF1034 and the portable frequency meter TF1026 (series). The wavemeter is a double-cavity instrument designed for the measurement of frequencies in the range 32 000 to 35 500Mc/s. One tunable cavity forms a transmission-type wave-

meter of relatively low Q and is fitted with couplings for insertion in a waveguide circuit. The second cavity is coupled to the first and forms a supplementary wavemeter of the absorption type; independently variable, and of high Q, this second cavity can be tuned to produce a sharp reaction within the pass-band of the first cavity.

The latest addition to the range of voltage measuring equipment is the valve voltmeter TF1041 (*illustrated below*). This instrument measures up to 300V and 700Mc/s unbalanced, in six ranges; d.c. up to 1 000V balanced or unbalanced, in seven ranges. There are seven other ranges for the measurement of resistances between 0·2Ω and 500MΩ. A feature of the instrument is the large meter for fast and precise reading.

Marconi Instruments Ltd.,
St. Albans,
Hertfordshire.

Multicore (69)

A NEW type of Ersin Multicore solder which will be shown, containing five cores of the extra fast non-corrosive type 362 flux, is known as Savbit Alloy and contains approximately 2 per cent copper and is claimed to increase the useful life of a soldering bit by 10 times. This special alloy is already in production and can be supplied in nominal tin content alloys of 60, 50 and 40 per cent. There is no appreciable difference in melting points between Savbit alloys and conventional tin-lead alloys.

A solder containing silver for use on silver-plated ceramics and a complete fluxing and soldering process for use with printed circuits, will be shown.

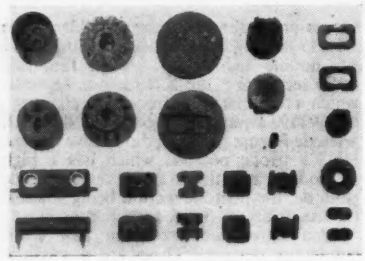
Multicore Solders Ltd.,
Multicore Works,
Maylands Avenue,
Hemel Hempstead,
Hertfordshire.

Mycalex (3)

A NEW glass-bonded insulating material known as Mycalon will be shown.

This material was evolved in conjunction with the Ministry of Supply, S.R.D.E., Christchurch, to meet service requirements under tropical and arctic conditions and, generally speaking, components requiring to be graded as H.1 can include Mycalon.

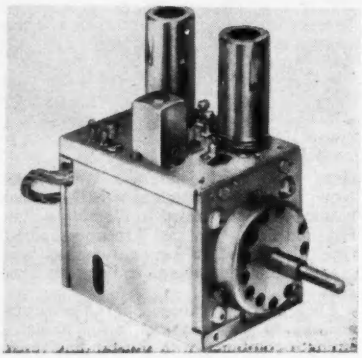
After subjection to six humidity cycles in the standard chamber to RCS11, Mycalon recovers to its full resistivity value within one hour and, upon removal from the testing chamber, the immediate figures are not lower than $10^{11}\Omega$, their full value when



dry being greater than $10^{14}\Omega$. The permittivity and power factor are lower, resulting in a loss factor of approximately half that of the existing grade on Injection Moulded Mycalex.

Mycalon can be injection or transfer moulded into any required shape, and to the finest tolerances desired because it does not shrink or distort after moulding. *Illustrated above* are some typical Mycalon components.

Mycalex and T.I.M. Ltd.,
Ashcroft Road,
Cirencester,
Gloucestershire.



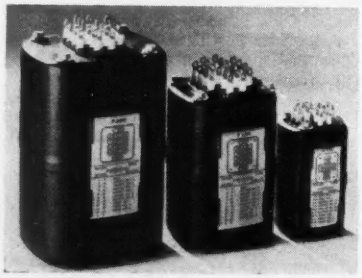
N.S.F. (49)

IN addition to a wide range of switches the N.S.F.-Oak switch type cascode television tuner will be shown (*illustrated above*). This is available in two versions, type 12K13 covering five channels in Band 1 and eight channels in Band 3, and type 12K14 with an additional switching position which will enable it easily to be converted to u.h.f. working.

N.S.F. Ltd.,
9 Stratford Place,
London, W.1.

Parmeko (27)

A SPECIAL display this year will be made of the Saturn Series Transductors for Magnetic Amplifier Applications. *Illustrated below left* are three typical transductors from the standard range developed by Parmeko in collaboration with the Royal Aircraft Establishment. This range complies with the Joint Services Specification RCL(PROV) 217 and comprises auto-excited transductors of the push-pull input and single-and three-phase output types.



Also to be shown is a range of transformers designed specifically for use with printed circuits and a range meeting American service specifications.

Parmeko Ltd.,
Percy Road,
Aylestone Park,
Leicester.

Pye (96)

EIGHT members of the Pye group of companies will be exhibiting at this year's exhibition.

W. G. Pye & Co. Ltd. are showing an audio frequency oscillator with a frequency range of 20 to 20 000c/s and an output continuously variable from 0 to 20V peak-to-peak, electrostatic voltmeters covering ranges from 1 to 18kV, and a d.c. microvoltmeter which has a full scale range of 20μV and adjustment to reduce sensitivity by factors of 1/10, 1/100 and 1/1 000.

Magnetic Devices Ltd. are showing a range of relays for both a.c. and d.c. supplies and a special relay for r.f. switching. Prominent among the new products are a sensitive type of relay for electronic circuit applications and a hermetically sealed plug-in miniature relay.

Power Controls Ltd. display a range of multi-way plugs and sockets particularly suited to rack-mounted equipment and miniature hermetically sealed coaxial plugs and sockets for Uniradio 43 cables.

Labgear (Cambridge) Ltd. are showing a range of wire-wound resistors, two types of television receiver filter, for reducing interference to television from nearby radio transmitters operating at frequencies lower than 30Mc/s or higher than 70Mc/s, a standing wave ratio indicator, and a crystal oven, with a temperature differential of 1.5°C, which operates from a 6·3V supply.

Cathodeon Ltd. exhibit a wide range of glass-to-metal seals, aerial changeover relays and thermal delay switches.

Pye Industrial Electronics Ltd. are making their first appearance at this exhibition and are showing a number of types of junction transistors which are intended primarily for hearing aid and low-powered audio frequency application and are all hermetically sealed.

Cathodeon Crystals Ltd. are exhibiting a range of quartz crystals for frequency control. All are hermetically sealed and in general adhere to requirements of the inter-services specification.

Pye Ltd., Switch Division, add a further sixteen types to their already considerable range of industrial and aircraft micro-switches.

Pye Ltd.,
Cambridge.

Salford (34)

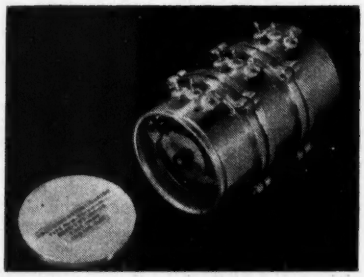
NEW products displayed will include a range of precision potentiometers with metal housings. Available in both linear and functional card winding types, these units employ an improved type of wiper assembly, in which the wiper, being horizontal, gives a more even tracking over the resistance winding. On the twin wiper

arm type, the second arm is now capable of independent movement through 230°, whereas the standard units in the past were limited to a 90° or 180° movement.

An improved method of ganging is also used and this makes for a more compact assembly as well as permitting the housings to be rotated individually for calibration purposes. A servo mounting spigot is mounted concentrically with the housing and a rotary clamping plate can be fitted for applications where the body of the potentiometer has to be rotated before clamping. A high grade bakelite former is used in the general-purpose units. Special formers are available for applications involving ambient temperature variations as wide as from −20°C to +85°C.

(Illustrated below)

Salford Electrical Instruments Ltd.,
Magnet House,
Kingsway,
London, W.C.2.



Stability Radio (51)

STABILITY Radio Components are showing beside their silvered mica capacitors a range of ceramic tubular capacitors rated at 100°C. These are inexpensive, robust and fully insulated components which cannot be damaged by prolonged contact with the soldering iron. Capacitance values are from 0·5pF to 0·005μF.

A new introduction for f.m. and Band 3 receivers is the " top coupling " range from 0·5pF to 1·5pF, which is supplied at an economic price with a tolerance of +0·1F.

Stability Radio Components Ltd.,
Commerce Estate,
Woodford Avenue,
London, E.18.

S.T.C. (62)

A RANGE of selenium and germanium rectifiers, Unistors, Thermistors, photocells, tantalum capacitors and quartz crystals will be shown.

Overtone crystals are now available in production quantities up to 55Mc/s. This frequency will shortly be extended, and to aid equipment designers, laboratory samples can be supplied at frequencies as high as 200Mc/s. The crystal oscillates in the third, fifth or higher overtone mode, thus the frequency of vibration is increased above the fundamental frequency approximately by the order of overtone employed. The circuit must be tuned in some manner to discriminate between the fundamental frequency and the desired overtone. The units are robust, stable and exhibit favourable electrical characteristics.

Standard Telephones & Cables Ltd.,
Connaught House,
Aldwych,
London, W.C.2.

T.C.C. (54)

AMONG the new components shown by T.C.C. will be a range of low leakage high quality electrolytic capacitors known as Superlytics ; these are of particular interest to designers of low frequency amplifiers, for grid coupling purposes..

The outstanding feature of these capacitors is their exceptionally low leakage which is such that for the first time it is possible to think in terms of insulation resistance of an electrolytic capacitor. Measurements taken have resulted in *IR* figures which are comparable with the standard paper dielectric capacitors. This characteristic results in a very long working life, and renders them suitable for operation at temperatures up to +85°C without voltage derating.

Also on display will be a range of subminiature electrolytic capacitors type CE58. These components measure only ½in by ¼in and are intended for use in transistor circuits.

In order to comply with RCS132 moulded Plimoseal silvered mica capacitors are introduced. This method of protection not only prevents the ingress of moisture, it also improves the insulation resistance and power factor, without impairing the inherent stability of the capacitor unit.

In addition, various types of capacitors conforming to American specifications, a wide range of printed circuits and capacitors for use therein, will be shown.

The Telegraph Condenser Co. Ltd.,
North Acton,
London, W.3.

Steatite and Porcelain (38)

INCLUDED in the materials on this stand will be Faradex H, a high permittivity ceramic (K=3200) and Frequentite S, a material of extremely low dielectric loss which, being non-porous, is particularly suited for vacuum applications such as u.h.f. valve envelopes, magnetron windows, etc. Process improvements such as metallizing and machining of ceramics, will be shown.

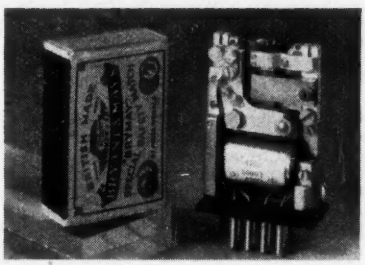
Steatite and Porcelain Products Ltd.,
Stourport-on-Severn,
Worcestershire.

T.M.C. (33)

" HIQUOR " powder cores will be shown in a large range of sizes with permeabilities from 15 to 125. These cores have a very low loss factor at frequencies up to 1Mc/s.

A range of metallized paper, polystyrene and American type capacitors will be exhibited.

Continuous development in the design of Carpenter polarized relays (*illustrated below*) is resulting in improved performance and stability over an extended temperature range. One of the main advantages of the relays is their high degree of sensitivity and working models will show them operating from a thermo-couple junction, and a photo-electric cell.



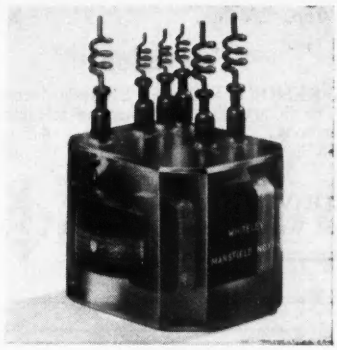
Telephone Manufacturing Co. Ltd.,
Hollingsworth Works,
Martell Road,
London, S.E.21.

Vactite (7)

THIS company will be exhibiting their Vacrom (nickel-chrome) and Eureka (cupro-nickel) resistance wires and tapes, pure nickel wires and tapes, molybdenum rods, wires and tapes and special wires for the radio valve industry.

Vactite have made a special study of superfine resistance wires and welcome inquiries for sizes in the ' triple O' range.

Vactite Wire Co. Ltd.,
24 Queen Anne's Gate,
London, S.W.1.



Whiteley (14)

THE range of Stentorian loudspeakers in sizes from 2½ to 18 in will be shown together with a wide variety of television and radio components including components potted in Polythene, Araldite and Marco resin. A C-core transformer moulded in Araldite and fitted with waterproof plugs and sockets is *illustrated above.*

Whiteley Electrical Radio Co. Ltd.,
Radio Works,
Victoria Street,
Mansfield, Notts.

Westinghouse (22)

A COMPREHENSIVE display of Westalite rectifier units will include a number of new miniature assemblies in various types of sealed housings. All of the new miniature rectifiers contain either double- or quadruple-voltage elements capable of withstanding peak inverse voltages of 42 and 85V respectively.

Westalite rectifiers for radio and television anode supplies will include both the usual spindle types and the newly developed contact cooled rectifiers for chassis mounting. The latter rectifiers dissipate their losses through the chassis and therefore effect a considerable saving in space, and increased efficiency.

Rectifiers for industrial d.c. power supplies and tropical type units will also be shown.

Westinghouse Brake & Signal Co. Ltd.,
82 York Way,
King's Cross,
London, N.1.

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Radar-Antennas

6

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BOOK REVIEWS

Electronics: Electrical Engineering Approach

By George F. Corcoran and Henry W. Price. 459 pp., 120 figs. Demy 8vo. John Wiley & Sons, Inc. Chapman & Hall Ltd. 1954. Price 56s.

THIS book would be more correctly named "Electronic Circuits" since the space devoted to the physics of the subject is relatively small, as the authors themselves admit.

A very brief summary of basic electrical theory and a glance at the electronic structure of the atom lead to a treatment of electron-movement with examples based on the cathode-ray oscillograph. A qualitative description of the effects of space charge in the vacuum diode introduces a fairly extensive section on rectifier circuits and other applications of the diode. The internal aspects of the triode are dismissed rather briefly but a full account of equivalent circuits for triodes is given. Tetrodes and pentodes are next introduced and a detailed chapter follows dealing with various types of class A amplifier. The treatment relies almost exclusively on the equivalent circuit with the associated complex algebra, graphical methods being avoided. A few special cases such at the cathode-follower, reactance-valve circuits and paraphase circuits are followed by a section on systematic methods of analysing complicated equivalent circuits. A note on noise is included.

Load lines are first used in the chapter on class A and class B power amplifiers. Load ellipses and composite characteristics (for push-pull stages) are also described. In the well-written chapter on feedback all the important points are quantitatively treated with the exception of the Nyquist criterion which is, perhaps wisely, stated without proof. A return to physics (excitation, ionization, etc.) heralds a treatment of the voltage stabilizer. A few words on gasfilled rectifiers and thyratrons lead to a second section on rectifier circuits.

Perhaps the chief attraction in the book is the very detailed chapter on germanium diodes and transistors. A simple but adequate account of the physics of germanium is first given and then the principles and practice of these relatively new devices is painstakingly explained. The last chapter, on oscillators, is somewhat surprisingly separated by over 100 pages from that on feedback and thus illustrates the slightly haphazard plan of the book as a whole. We find, for example, smoothing circuits treated partly under the vacuum diode and partly under gas-filled rectifiers, while paraphase amplifiers also appear in two instalments.

Perhaps the least satisfactory part of this book is that which purports to deal with fundamentals. Apart from being condensed to an absurd degree it exhibits that vagueness which usually accompanies the m.k.s. system of units in dealing with basic matters. For example, field strength (H) is defined as rate of variation of ampere-turns with distances, a meaningless definition resulting from the fashionable abhorrence of the magnetic pole. It is symptomatic that Gauss's theorem does not qualify for a place among the fundamentals but creeps in apologetically as a footnote.

One cannot hope at this date for a change in the unmethodical American practice of calling a bi-phase half-wave rectifier circuit a "full-wave" circuit, but it is disappointing to find a paraphase amplifier called an "inverter," especially in view of the fact that the device properly called an inverter is not mentioned.

The chief characteristic of this book is a most praiseworthy thoroughness in matters of practical application. With numerous worked examples the authors show clearly how to tackle a variety of real-life problems. Many pages of examples for the student are also provided. Indeed, this thoroughness is partly responsible for the rather limited scope of the book. One might expect to find something about modulation, pulse generation, sweep circuits and other familiar matters in a volume of this size, but they do not appear.

The printing and binding are so good as to compensate in some degree for the high price, but intending purchasers would be well advised to compare the scope of this book with that of similar books by British authors, who are compelled by circumstances to practice the art of condensation.

K. A. MACFADYEN.

Elektromagnetische Wellen (Electromagnetic Waves)

By Karl Wagner. 267 pp., 185 figs. Demy 8vo. Verlag Birkhäuser. Basel. 1953. Price Sfr.33.30 bound, Sfr.29.10 paper cover.

THIS book, carrying the sub-title "An introduction to the theory as basis to its application in electrical transmission technique," is the outcome of lecture courses which the late Professor Wagner held in Sweden, Italy and Spain between 1947 and 1951. It may be considered as the swan song of a scientist and engineer whose many contributions to the development of electrical communication and power engineering are well known to all those who have followed with interest, since the publication of his first book *Electromagnetic Transients in Overhead Lines and Cables in* 1908, the brilliant career of one of the foremost German authorities in these fields within the last half century.

It is not a book for the beginner and a sound knowledge of Maxwell's theory, of vector analysis, of the theory of functions, of quadrupole theory and the like is required for its full understanding. It is perhaps a sign of the high standard of technical education on the Continent that in the author's opinion the mathematical background expected from the reader scarcely exceeds what is required for the intermediate examination of an engineering student.

A brief account of the main contents of the book will show its wide scope. The first chapter, dealing with plane waves in free space, shows after a brief historical introduction how waves are propagated. The wave equations are derived for constant and periodically varying fields. Linear and elliptical polarization and phase and group velocities are discussed.

The second chapter is devoted to reflexion and diffraction of electromagnetic waves. Various cases are discussed, e.g. that of vertical incidence, the case in which the reflected wave is extinguished, the total reflexion and the case when the refraction ratio is complex.

In dealing with waves conducted by wires in the third chapter, which is of particular interest for the power engineer, the telegraph equation is derived and the theory of travelling waves is given together with some examples of such waves, e.g. those caused by lightning or by switching operations. The effect of protective capacitors and chokes and the overvoltages caused by interrupting a short-circuit are discussed. In dealing with periodical waves on wires the spiral diagram illustrating amount and phase of voltage and current at any point of the line is explained. Propagation-, phase- and attenuation-constants and characteristic impedance are calculated. The line is then treated as a quadrupole and it is shown how its characteristic values may be determined by no-load and short-circuit test. Examples of "short" and "long" lines are given and the consideration of standing waves illustrates the use of Lecher wires. A comparatively large section deals with the application of the theory to aerials. The skin effect in cylindrical conductors is briefly dealt with and inhomogeneous conductors, i.e. those in which the line parameters vary from point to point are given due consideration.

In the fourth chapter bunched conductors are dealt with and the mutual interference between a power and a telegraph line is investigated as an example.

The fifth chapter is devoted to waves in hollow conductors. E-waves and H-waves in circular, rectangular and square conductors and their attenuation, hollow conductors used as resonators and their properties considered as quadrupoles are discussed.

The comparatively brief sixth chapter deals with electric and magnetic dipoles, e.g. those used as loop aerials.

The concluding seventh chapter is a comprehensive survey of electric waves in the ionosphere. Their field intensity, attenuation, polarization, limiting frequencies, reflexion and refraction. Graphs show the daily and annual changes of the limiting frequencies in the various regions of the ionosphere. The effects of eclipses and of the number of sunspots and of other ionospheric disturbances are described and a brief final section deals with the transmission of electromagnetic waves through the ionosphere.

A name and a subject index are provided. The book is well produced and should prove helpful not only to the advanced student but also to practical research workers both in power and communication engineering.

R. NEUMANN.

Telecommunications

By A. T. Starr. 455 pp., 65 figs. Demy 8vo. Sir Isaac Pitman & Sons Ltd. 1954. Price 35s.

THIS book is said to be written to cover the syllabus for the subject of telecommunications in the London University Degree. No doubt a student would like to think that for 35s. he could buy all the knowledge needed for one subject of his university degree, but most university teachers would prefer that he should acquire the habit of using specialized treatises and original papers for reference: the greatest fault of Dr. Starr's book is that it appears to have no references whatsoever to the rest of the literature. Moreover, in so encyclopaedic a book there are naturally some topics which are less fully covered than others, and here a pointer to other sources is essential. Without taking advantage of one's own special interests, one can cite "Radio Position and Direction Finding," which is given four and a half pages with the barest mention of the screened loop and no suggestion that the e.m.f. is calculable from the magnetic component of the incident wave. Again, those of us who dabble only in radio might be forgiven heretical views on the neper, but a book which covers also line communication should adhere to the definition that the neper is a logarithmic unit of current ratio, not of power like the decibel.

The book includes mathematic appendices on Heaviside's operational calculus, the Laplace transform and vector fields, but no guide to matrix notation which slips unannounced into pages 166-168. But despite all its faults, it must be agreed that this book has achieved something in presenting in a single volume a comprehensive survey of the field of telecommunication. It includes clear descriptions and drawings of relays, switches and teleprinter mechanisms which are so rarely described in books, and the longest chapter in the book is on "Lines and Transmission Networks," a subject in which Dr. Starr is an acknowledged authority. Among the topics covered in other chapters are acoustics, television, electromagnetic waves and microwave technique with a 6-page appendix on "Waveguide Theory" so that any student who is well versed in all the topics discussed in this book should be equipped to face both examinations and real-life problems in telecommunications.

D. A. BELL.

Kempe's Engineers' Year Book 1955

1,345 and 1,413 pp. Crown 8vo. (Two volumes in case). 60th Edition. Morgan Bros. (Publishers) Ltd. Price 75s.

THE preface to the 1955 Kempe states that last year's edition was so completely revised that this year attention has been primarily confined to detail. Only minor changes, therefore, occur in the edition under review and the most significant in the chapter on Electronic Engineering is no more than a new paragraph under the sub-heading of Colour Television.

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LETTERS TO THE EDITOR

(We do not hold ourselves responsible for the opinions of our correspondents)

A Versatile Pulse Shaper

DEAR SIR,—With reference to the article by Mr. Kaufer in the February issue (p. 78), this circuit was tried in the laboratory several years ago. It was found that for precise operation the blocking oscillator could be superior to the thyratron due to the firing time delay with the latter type of pulse former. There was an appreciable time delay between the top of the leading edge of the trigger pulse and the output pulse. A graph shows this for a sample 2D21 (CV797). There were also considerable differences between other samples of this valve and firing delays up to 1·5Mc/s could be obtained. Although an output pulse could not be obtained by applying

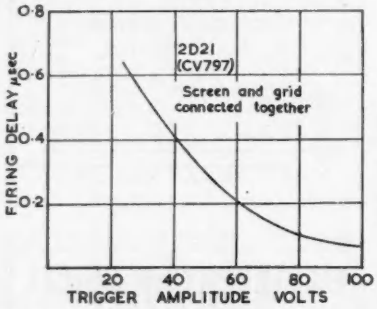

Fig. 1. Firing delay/trigger amplitude for 2D21

a trigger pulse to the screen only, it was possible to "gate" the valve with the screen providing the gating waveform was slightly in advance of the main trigger pulse.

Yours faithfully,

K. E. WOOD,

Leatherhead,
Surrey.

High-Speed Magnetic Amplifiers

DEAR SIR,—Mr. A. E. Maine in his article on high-speed magnetic amplifiers (page 514 of the December issue) describes two methods of coupling Ramey-type amplifiers. Another method is to use a pnp junction transistor, arranged as shown in Fig. 1, as the coupling device.

The transistor X_2 normally has a high impedance between base and collector so that the re-setting voltage for core 2 is absorbed by the transistor. When core 1 fires it delivers a large emitter current to the transistor X_2 decreasing its collector-to-base resistance so that the re-setting voltage is applied to the second core. In this way the degree of re-setting of core 2 depends on the firing angle of core 1, which in its turn can be controlled either with a voltage signal or another transistor used as a controlling element. The sequence of waveforms in Fig. 2 shows how the re-setting voltage to core 2 is absorbed by the transistor to an extent depending on the firing angle of core 1. The small voltage pulse before the main collector voltage wave is due to Z_1 being largely capacitive, and the incomplete voltage waveforms and the incomplete current waveform of Fig. 2(a) are attributed to the poor rectangularity of core material used. The supply frequency is 2 500c/s.

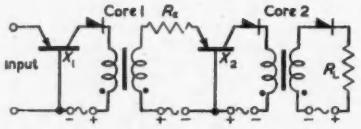

Fig. 1. Transistor coupled Ramey amplifier

When the re-setting of the first core is voltage controlled the coupling arrangement retains the linear relation between the mean input and output voltages, except in as much that the output voltage decreases with increasing voltage input. This property reduces the biasing requirements when the first stage is controlled by a valve or transistor.

The waveforms of Fig. 2 show that high collector currents and voltages do

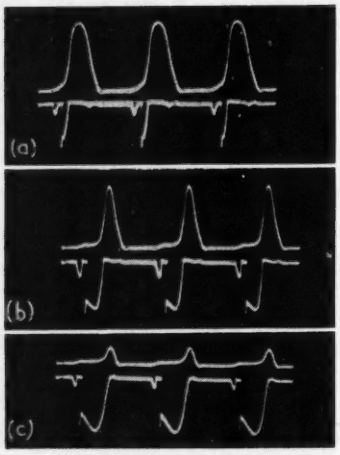

Fig. 2. Waveforms showing variations of the emitter current (top) and collector voltage (bottom) of the coupling transistor V, as the emitter current of the controlling transistor X, is increased from zero

not occur simultaneously. This enables transistors with low power ratings to couple circuits controlling much larger powers.

Yours faithfully,

R. E. WRIGHT,

The General Electric Co. Ltd,
Stanmore.

An A.C. Voltage Stabilizer

DEAR SIR,—In my article published in the April 1954 issue it was pointed out that the r.m.s. output voltage of the stabilizer could be affected by changes in the peak factor of the voltage waveform, since it is the peak value which is controlled. Under normal circumstances this characteristic will not cause any trouble. Changes in the peak factor of supply lines are very uncommon, and the waveforms of auxiliary generating sets, which are often not truly sinusoidal, rarely change sufficiently to result in significant changes in stabilizer output voltage. However, the distortion frequently present in the waveforms of small a.c. generators could cause trouble should a stabilizer be expected to hold the output voltage constant irrespective of whether the source is the normal supply line, or (in the event of a power failure) an auxiliary generating set.

The distortion present in the voltage waveforms of such generators is usually due to the presence of a small percentage of the third harmonic, plus very small amounts (normally insignificant) of the second and fifth harmonics. If. as is usually the case, this third harmonic is in phase with the fundamental, the r.m.s. voltage for a given peak value is proportionately higher. Thus it can be seen, for example, that the introduction of 5 per cent of the third harmonic (a not uncommon amount) would result in the output voltage of one of the above stabilizers rising by nearly 12V.

Neglecting the other harmonics, and letting k represent the percentage of the third present (in phase), it can be shown that the r.m.s. and average values of the voltage (V_r and V_a respectively) of such a distorted wave, in terms of the actual peak value (V_p), are given by the following expressions (for k not greater than 11·1 per cent):

$$V_r = \frac{\sqrt{(10\,000+k^2)}}{\sqrt{2}(100-k)}V \quad \ldots\ldots\ldots (1)$$

and $$V_a = \frac{300+k}{1{\cdot}5\pi(100-k)}V_p \quad \ldots\ldots\ldots (2)$$

From equations (1) and (2)

$$V_r = \frac{1{\cdot}5\pi\sqrt{(10{,}000+k^2)}}{\sqrt{2}(300+k)}V_a \quad \ldots\ldots (3)$$

By giving k in equation (1) and (3) various values from 0 to 10, and putting the results so obtained in terms of $V_r = 100$ for $k=0$, the following table is obtained.

This table shows how, if the peak value is held constant, the r.m.s. value rises as the percentage of third harmonic increases, whereas if the average value is controlled, the r.m.s. value falls. Therefore, for any particular amount of third harmonic it is possible, by making the voltage control unit of the stabilizer operate at a voltage appropriately disposed between the peak and average values, to hold the r.m.s output voltage

k	Vr for constant Vp (from equation 1)		Vr for constant Va (from equation 3)	
PERCENTAGE 3RD HARMONIC	RELATIVE VALUE	PERCENTAGE RISE	RELATIVE VALUE	PERCENTAGE FALL
0	100·0	·0	100·0	0·0
1	101·0	1·0	99·7	0·3
2	102·1	2·1	99·3	0·7
3	103·1	3·1	99·0	1·0
4	104·2	4·2	98·8	1·2
5	105·4	5·4	98·5	1·5
6	106·6	6·6	98·2	1·8
7	107·8	7·8	98·0	2·0
8	109·0	9·0	97·7	2·3
9	110·3	10·3	97·5	2·5
10	111·7	11·7	97·3	2·7

constant irrespective of whether the harmonic is present or not.

Perhaps this principle may best be illustrated by an example. With C_1* of nominal value 16μF, the d.c. voltage across the bridge circuit of the sensing unit is about 290V, being the peak value of the incoming 230V r.m.s. less a voltage drop in the rectifier MR_1. With $C_1 = 0$, this voltage is about 190V, being the average value of the 230V r.m.s. less a voltage drop due to the regulation characteristics of the system. If it is desired that the voltage across C_1, and hence across the bridge circuit of the voltage sensing unit, should be the same irrespective of whether the incoming a.c. is truly sinusoidal or contains, say, 4 per cent of the third harmonic, then this voltage should be

$$190 + \left(\frac{(1{\cdot}2)}{(4{\cdot}2 + 1{\cdot}2)}\right)(290 - 190) = 212\text{V}.$$

To achieve this effect C_1 should have a value of 0·5μF. (As a matter of interest, the control point of a stabilizer modified to give the correct r.m.s. output voltage when there is 4 per cent of harmonic present will not vary by more than $\pm$ 1 per cent for a range of harmonic content from 0 to about 8 per cent.)

Consequent upon such an alteration being made to the voltage controlling unit, several other minor ones become necessary. The ratio of the divider system R_3, R_4, VR_1, R_5, R_6 needs to be changed; R_1 and R_2 both need to be reduced; an additional 0·5 MΩ resistor needs to be connected between C_1 (+) and the ignition electrode of V to ensure reliable ignition of V (since the voltage across it now drops below its operating point twice per cycle); and additional biasing of the moving-coil relay A is necessary to prevent chattering of its contacts (because of vibration caused by the 100c/s component now present). Typical values for the particular case quoted above are $R_4 = 5\text{k}\Omega$, $R_1 = 10\text{k}\Omega$, $R_2 = 15\text{k}\Omega$, R_3 and $R_6 = 330\Omega$.

Yours faithfully,

R. G. ACKLAND,
Defence Standards Laboratories,
Victoria,
Australia.

* Ref. Fig. 3, *Electronic Engng.* 26, 144 (1954).

Computers and Computors

DEAR SIR,—I presume Mr. Puckle would have his computor operated by an "operater," and would refer to you, Sir, as an "editer" so as to leave the word "editor" for a device used to check the punched tapes fed to his machine.

It is not strictly true that the words "computer" and "computor" are different—rather are they alternative spellings of the same. Nevertheless, I agree that there is a case for a convention of the type suggested, and in fact this appears to be already fairly well established, in the opposite sense to that proposed by Mr. Puckle.

Yours faithfully,

B. M. ADKINS,
Radlett,
Herts.

DEAR SIR,—I was sorry to read Mr. Puckle's letter in the February issue, claiming that there are two words "computer" and "computor." There is, in fact, only one accepted word (see the recognized English dictionaries), viz., "computer," which covers both the man and the machine, and the large majority of people consider "computor" merely a spelling mistake.

It is quite legitimate for a profession to coin a new word if confusion can arise between two different senses of the word as it is generally used. Any such step, however, should be taken only with agreement throughout the profession, because the English language covers the whole of the earth and divergences in spelling or meaning in different localities are obviously undesirable. No such agreement on "computor" has been given or even sought.

I submit that no confusion arises in practice between the man and the machine, the most convincing proof being that even those who make a difference in spelling usually make no difference in pronunciation. If a new word were desirable, etymology would suggest "computator," not "computor"; the latter is etymologically shocking and is otherwise unsatisfactory because it would still leave confusion in the spoken word. A proposal was made a quarter of a century ago to reserve the termination "or" for the machine in a general way, and this is responsible for such currency as "computor" and "convertor" still have. The initiative, however, received very little support even in this country and none in the U.S.A. It was pointed out that there would be just as much reason for changing the spelling to "windscreen-wipor" for fear there should be confusion between the attachment to the motor-car and the garage attendant who cleans a wind-screen.

I hope Mr. Puckle will find it possible to drop "computor" which does not really do his job.

Yours faithfully,

E. H. ULLRICH,
Richmond, Surrey.

Correspondent replies:

DEAR SIR,—I much regret that I am unable to agree either with Mr. Ullrich or Mr. Adkins.

To take Mr. Adkins' letter first. He agrees that there is a case for a convention of the type suggested in my letter (February, 1955, issue) but he says that it is already established in the opposite sense. I maintain that since the two words "computer" and "computor" already exist there is no need for convention. Does Mr. Adkins suggest that "computor" is used to describe the user of the machine? It is precisely because I find that people are beginning to use the wrong spelling that I wrote my letter to you.

Mr. Ullrich's letter suggests that I have coined the word "computor." I thank him for the compliment but I must disclaim the honour. The only word I have coined which has come into general use is "sync" and, even then, I spelled it "synch." I still consider that the "h" is necessary to harden the "c," but at least I have got 80 per cent agreement! Mr. Ullrich's humorous effort, "windscreen wipor" made me chuckle but does not affect the issue. The English language has many words whose spelling appears to be wayward but, nevertheless, it seems to me to be a pity to debase it by wrong spelling or by the wrong use of words. It does not appear to me to be of any importance that a word is not accepted in the U.S.A., for their language has quite naturally gone along its own path; differences need not cause any confusion. An English "frame" and an American one in television engineering have quite different meanings yet we are not confused. Nor is it necessary for us to follow their lead when we have an existing word in our language. It certainly won't upset our friendship if we fail to copy them, in fact they will respect us all the more for having minds of our own.

I particularly dislike Mr. Ullrich's suggestion to use "computator" which would introduce another horror like "commentator." In this case, the correct word is "commentor."

I hope that Messrs. Ullrich and Adkins will reconsider the matter and eventually follow the lead given by THE TIMES and ELECTRONIC ENGINEERING.

Yours faithfully,

O. S. PUCKLE,
Beaconsfield,
Bucks.

Meetings this Month

THE BRITISH INSTITUTION OF RADIO ENGINEERS

Date: 13 April. Time: 6.30 p.m.
Held at: The London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1.
Discussion: The BBC V.H.F./F.M. Sound Broadcasting Service.
Opened by: K. R. Sturley.
Date: 27 April. (Time and place as above).
Lecture: Suppressed Aerials for the Aircraft H.F. Band.
By: K. J. Coppin.

North Eastern Section

Date: 13 April. Time: 6 p.m.
Held at: Neville Hall, Westgate Road, Newcastle-upon-Tyne.
Lecture: The Manchester University Electronic Computor.
By: E. T. Warburton.
Followed by Annual General Meeting.

Merseyside Section

Date: 21 April. Time: 7 p.m.
Held at: Riversdale Technical College, Riversdale Road, Liverpool 19.
Annual General Meeting followed by technical films.

South Wales Section

Date: 27 April. Time: 6.30 p.m.
Held at: Cardiff College of Technology, Cathays Park, Cardiff.
Lecture: Some Technical Problems in Sound and Television Broadcasting.
By: K. R. Sturley.

THE INSTITUTION OF ELECTRICAL ENGINEERS

All London meetings, unless otherwise stated, will be held at the Institution, commencing at 5.30 p.m.
Date: 21 April.
The Forty-Sixth Kelvin Lecture: Transistor Physics.
By: W. Shockley.

Measurements and Radio Sections joint meeting

Date: 5 April.
Lecture: High Speed Electronic Analogue Computing Techniques.
By: D. M. MacKay.

Measurements Section

Date: 19 April.
Discussion: The Measurement of Impulse Voltages and Currents with special reference to the testing of Surge Diverters.
By: R. Davis.

Radio Section

Date: 20 April.
Lecture: A Study of the Long-Term Emission Behaviour of an Oxide Cathode Valve.

North Eastern Radio and Measurements Group

Date: 4 April.
Held at: King's College, Newcastle-upon-Tyne.
Annual General Meeting followed by
Lecture: Thermionic Valves of Improved Quality for Government and Industrial Purposes.
By: E. G. Rowe, P. Welch and W. W. Wright.

North Midland Centre

Date: 5 April. Time: 7 p.m.
Held at: The Station Hotel, York.
Lecture: The Possibilities of a Cross-Channel Power Link Between the British and French Supply Systems.
By: D. P. Sayers, M. E. Laborde and F. J. Lane.

South Midland Radio Group

Date: 25 April. Time: 6 p.m.
Held at: The James Watt Memorial Institute, Great Charles Street, Birmingham.
Annual General Meeting followed by
Lecture: A Transatlantic Telephone Cable.
By: M. J. Kelly, Sir W. Gordon Radley, G. W. Gilman and R. J. Halsey.

Southern Centre

Date: 1 April. Time: 6.30 p.m.
Held at: South Dorset Technical College, Weymouth.
Lecture: Cold Cathode Valves.
By: J. R. Acton.
Date: 13 April. Time: 6.30 p.m.
Lecture: Modern Developments in Atomic Energy.
By: T. E. Allibone.

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Date: 6 April. Time: 5 p.m.
Held at: The Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2.
Lecture: Regional Problems in the Provision and Maintenance of V.H.F., U.H.F. and S.H.F. Radio Links.
By: F. Moxon.

THE TELEVISION SOCIETY

Date: 1 April. Time: 7 p.m.
Held at: The Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, London, W.C.2.
Lecture: A Flying-spot (Mechau) Telecine System.
By: J. L. Bliss.
Date: 21 April. (Time and place as above).
Lecture: Progress in Colour Television.
By: L. C. Jesty.

PUBLICATIONS RECEIVED

THE COURTAULD ATOMIC MODELS is a a booklet describing what are believed to be the first models designed to incorporate an elastically-distortable bond of great use in the investigation of steric hindrances, developed in the Maidenhead laboratory of Courtaulds Ltd.

ERMA CATALOGUE of cable lugs, solderless terminals, crimping tools and equipment is a recent publication of Erma Ltd., Hong Kong Works, Exhibition Grounds, Wembley, Middlesex.

GREEN SEAL TRANSFORMERS is an illustrated booklet describing a series of tests carried out on transformers using new silicone insulation. This publication is obtainable free on application from Brentford Transformers Ltd., Kidbrooke Park Road, Kidbrooke, London, S.E.3.

STANDARDS AND MEASURING EQUIPMENT FOR ELECTRICAL RESEARCH AND TELECOMMUNICATION ENGINEERING is the new 1955 edition of the catalogue produced by H. W. Sullivan Ltd. It deals in a comprehensive manner with standards of resistance, capacitance and inductance of both fixed value and decade or continuously variable form. H. W. Sullivan Ltd., Leo Street, Peckham, London, S.E.15.

SOLDERLESS WIRING CONNECTION FOR LIGHT AND HEAVY DUTY is a booklet produced by the Plessey Company who pioneered and developed, primarily for the aircraft industry, the principle of solderless wiring connexion which ensures a reliable joint regardless of the skill of the operator, and which eliminates all troubles due to heat and the corrosive action of fluxes. Since then its use has been adapted to a much wider field of industrial application. The Plessey Co. Ltd., Ilford, Essex.

POLARIMETERS, HILGER PHOTOELECTRIC TRISTIMULUS COLORIMETER, SOME APPLICATIONS OF THE DIRECT READING ATTACHMENT TO THE MEDIUM QUARTZ SPECTROGRAPH, NEW HILGER SPEKKER PHOTOELECTRIC FLUORIMETER, are four recent publications of Hilger & Watts Ltd., Hilger Division, 98 St. Pancras Way, London, N.W.1.

TEN YEARS OF SEMI-CONDUCTING MATERIALS AND TRANSISTORS is a bibliography produced by the Research Department of Pye Ltd., Radio Works, Cambridge.

TELEVISION FIELD SERVICE MANUAL WITH TUBE LOCATIONS, TELEVISION MANUFACTURERS' RECEIVER TROUBLE CURES VOLUME 6 and ADVANCED TELEVISION SERVICING TECHNIQUES are recent publications applicable to American practice. John F. Rider Publisher, Inc., 480 Canal Street, New York, 13, U.S.A.

FROM SCHOOL TO PROFESSIONAL ENGINEERING is a booklet which aims to inform all those in public, secondary grammar and secondary technical schools of the opportunities which the Metropolitan-Vickers Electrical Company provides for training step by step with facilities for study in electrical and mechanical engineering, physics, chemistry and metallurgy. Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17.

CANADIAN MARCONI MAGAZINE, the first issue of which appeared in January, will be published five times yearly to inform readers about progress in the science and industry of electronics. Comments and suggestions are invited. Correspondence should be addressed to the Editor at Canadian Marconi Company Ltd., 2442 Trenton Avenue, Montreal 16, Quebec.

G.E.C. AIRPORT ELECTRIFICATION is a booklet in which the main emphasis has been placed on airport lighting, the various control systems used for this vital aspect of airport operation, on telecommunication and equipment peculiar to airports. A two runway airport, similar in size and layout to those in common use all over the world, has been taken as a basis for the illustration of various proposals, but such proposals are adaptable for any other layout. The General Electric Co. Ltd., Magnet House, Kingsway, London, W.C.2.

SPERRY SYNCHROS describes the range of instrument synchros manufactured by the Sperry Gyroscope Co. Ltd. It includes data sheets relating to the various models of synchros available from this Company and an explanation of how these units can be applied. The Sperry Gyroscope Co. Ltd., Great West Road, Brentford, Middlesex.

THE LONDON AND HOME COUNTIES BULLETIN OF SPECIAL COURSES IN HIGHER TECHNOLOGY for the Spring and Summer terms, 1955, is now available. Copies may be obtained from the Secretary, Regional Advisory Council, Tavistock House South, Tavistock Square, London, W.C.1, price 1s. 6d., post free.

A BIBLIOGRAPHY OF GUIDES FOR TECHNICAL AUTHORS has been reprinted from Aslib Proceedings, (Vol. 6, No. 4). It is restricted to books which are both readily available at the present time and which, in the experience of the compiler, have been found to offer most practical help to the technical author. Association of Special Libraries and Information Bureaux, 4 Palace Gate, London, W.8.

INTERNATIONAL JOURNAL OF ABSTRACTS ON STATISTICAL METHODS IN INDUSTRY No. 2 has recently been published by the International Statistical Institute, 2 Oostduinlaan, The Hague. Price of single copies 7s. 3d., annual subscription for three issues 18s.

ROHDE & SCHWARZ MITTEILUNGEN is the house journal of this German company which manufactures communications and laboratory instruments. The sole agents in this country are Aveley Electric Ltd., 44 Tottenham Court Road, London, W.1.

SILVER PLATING is a new booklet on the subject produced by Johnson Matthey & Co. Ltd. It is not intended to be an exhaustive treatise on the electrodeposition of silver, but deals in a practical manner with the various operations involved in silver plating, indicating suitable methods for most requirements and giving warnings of possible difficulties. The operation of silver plating may be sub-divided into three main sections—preparation, plating and finishing—and these are considered in the booklet under the appropriate headings. A further section deals with plating troubles, and useful appendices are included. The booklet, the reference number of which is 1851, is obtainable from the company free on request. Johnson, Matthey & Co. Ltd., 73-83 Hatton Garden, London, E.C.1.

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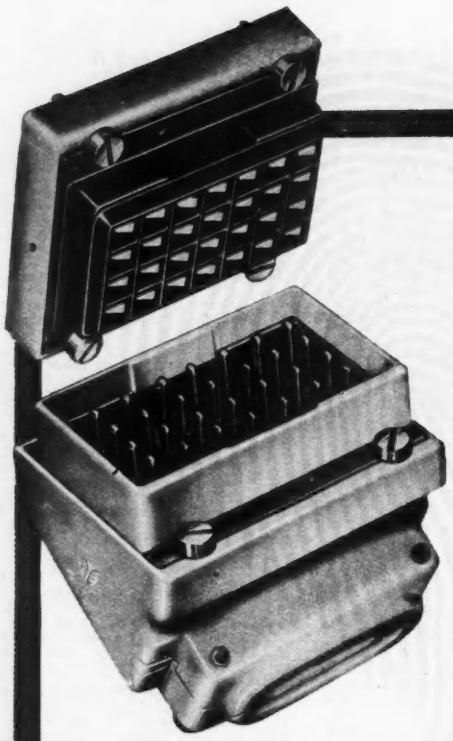

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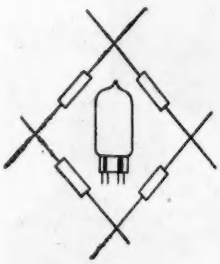

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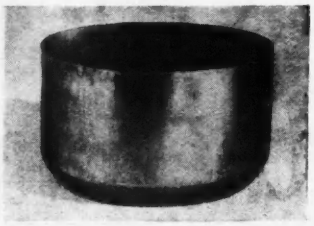

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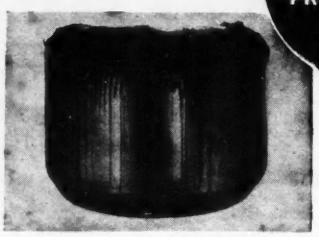

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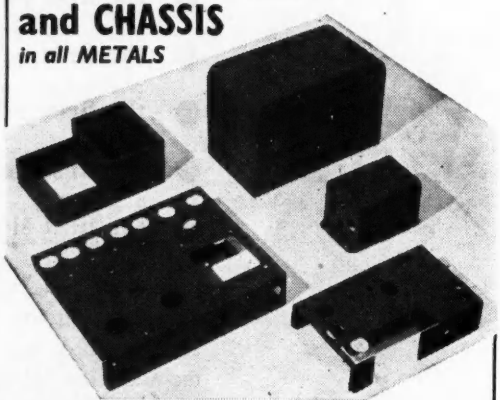

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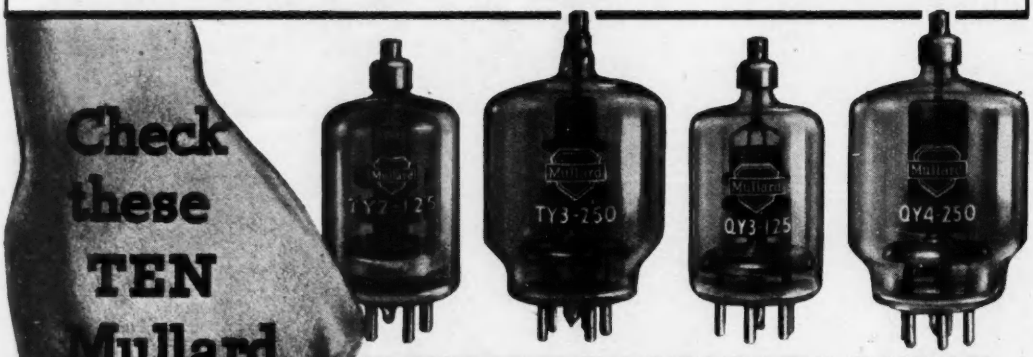

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TY2—125 (CV1924)	ampl.	2500	-200	205	40	390	310	76	200
TY3—250	ampl.	3000	-250	365	69	430	670	77	150
QY3—125 (CV2130)	ampl.	3000	-150	167	6.5	300	300	75	200
QY4—250 (CV2131)	ampl.	4000	-225	312	9	374	800	80	120

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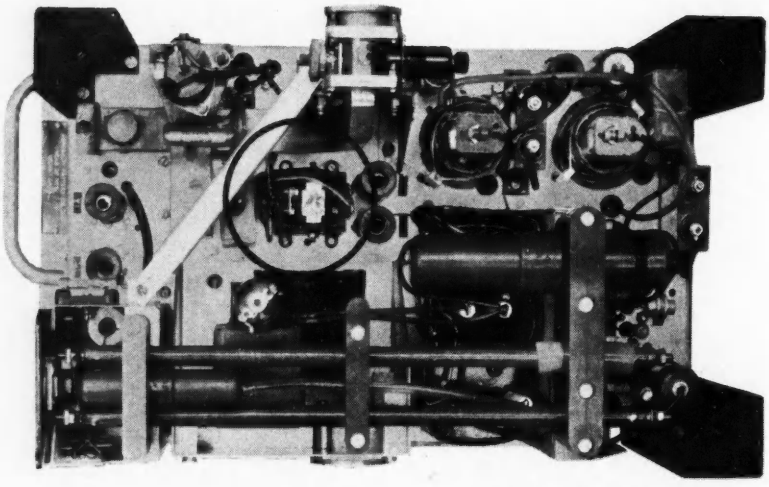

Decca Type 159B R.F. Unit Chassis incorporating Sunvic Time Delay
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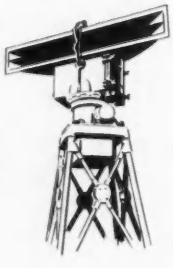

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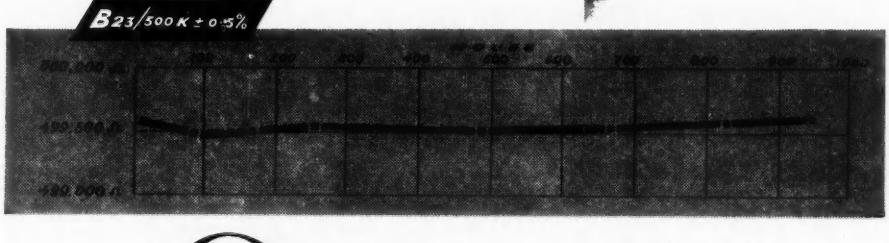

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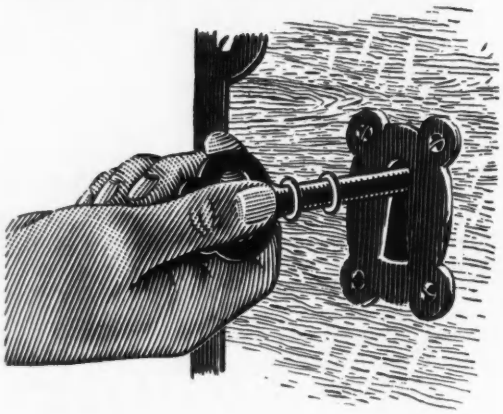

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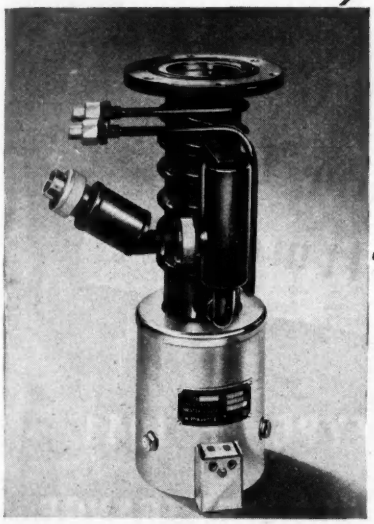

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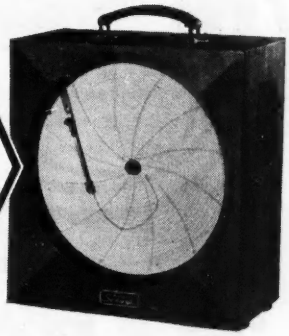

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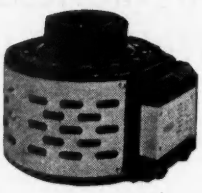

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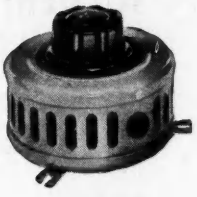

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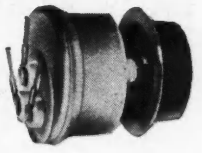

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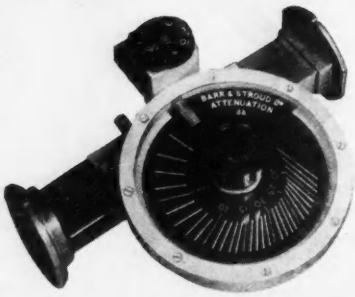

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Attenuation :	0-30 db.
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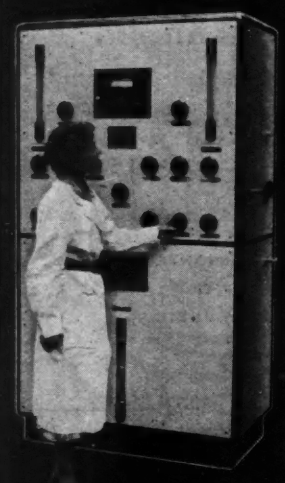

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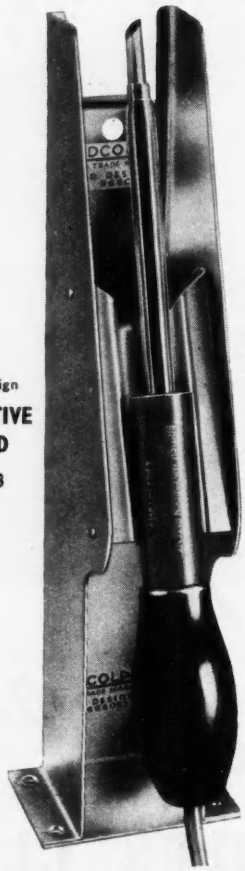

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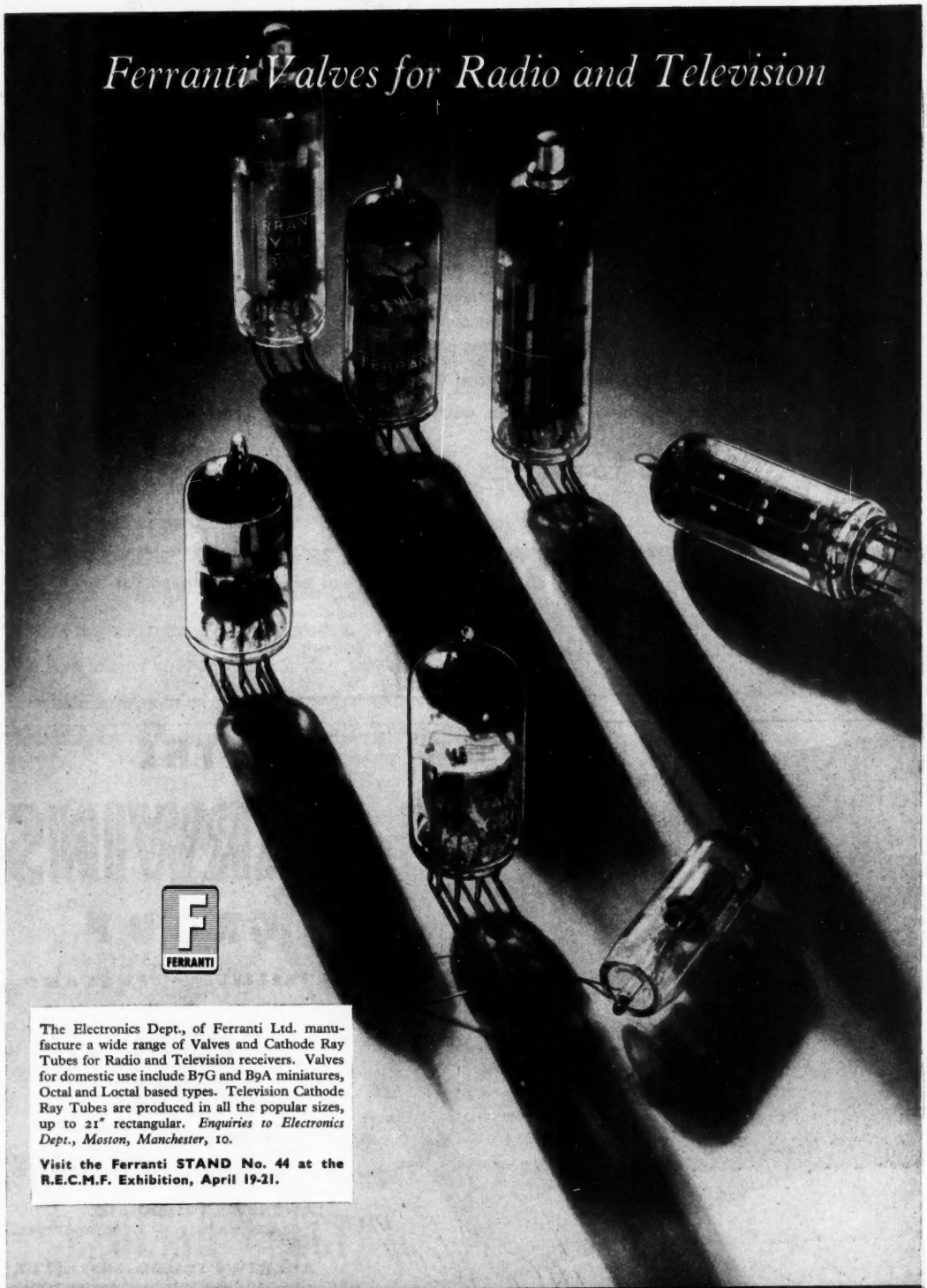

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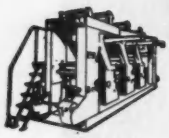

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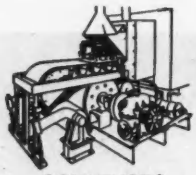

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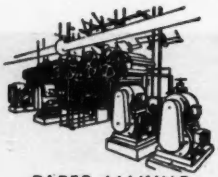

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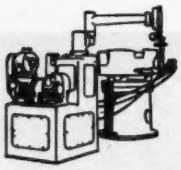

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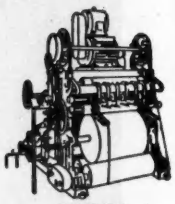

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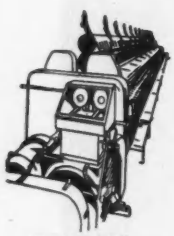

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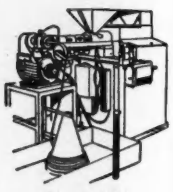

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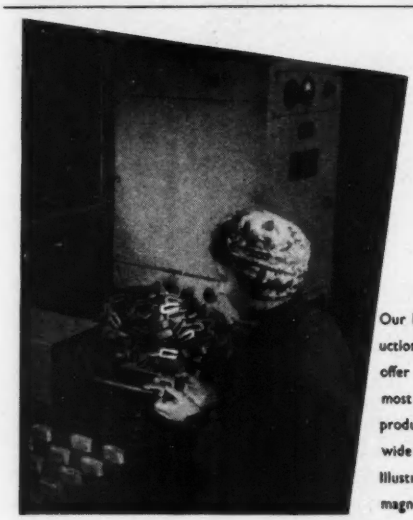

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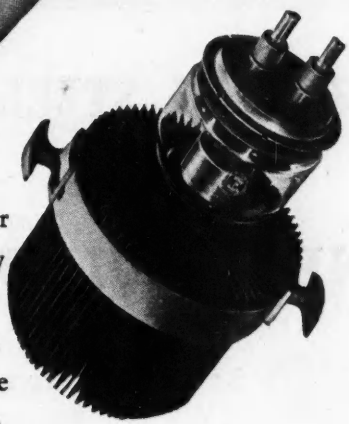

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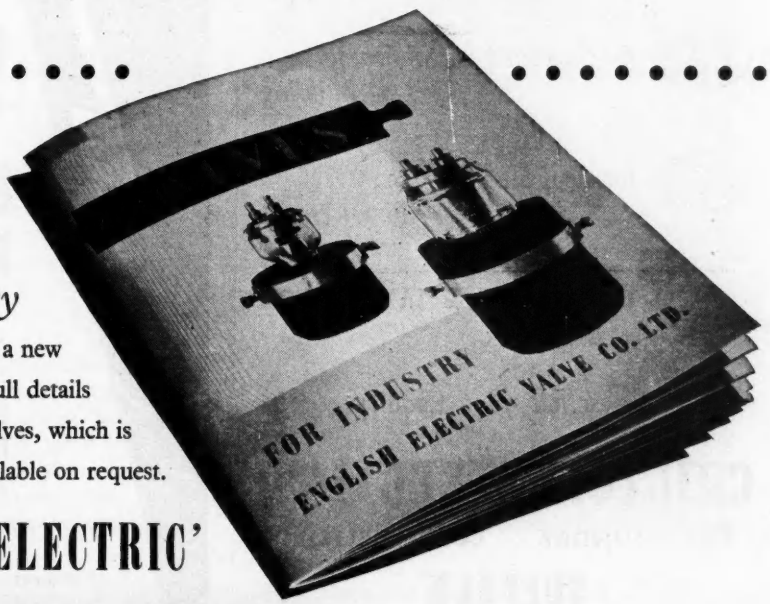

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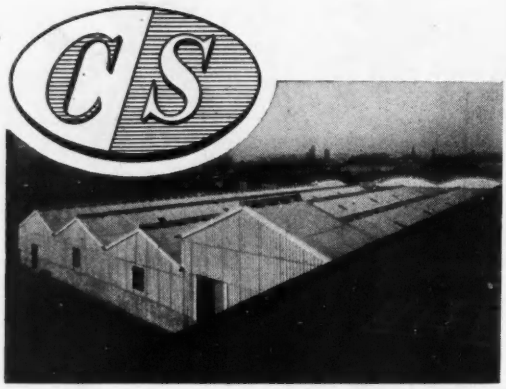

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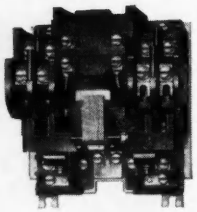

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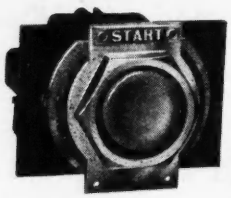

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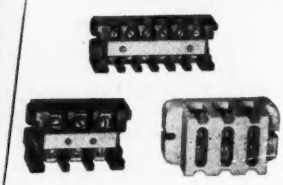

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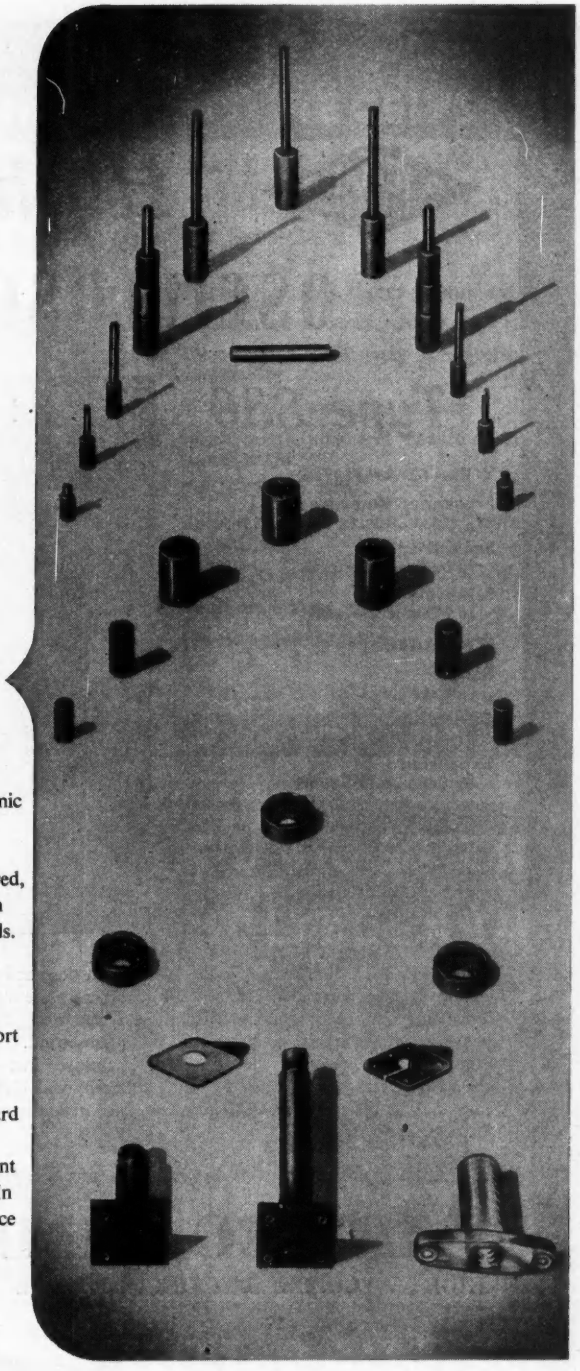
by Plessey



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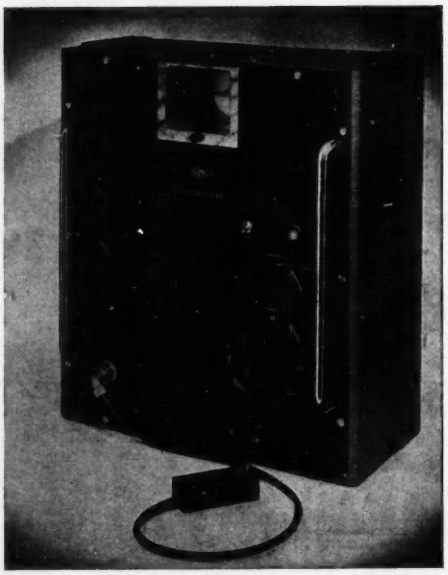
OSCILLOSCOPE

Type 830



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± 2.5 db from 30 c/s-20 Mc/s.

Sensitivity :
75 millivolts per cm.

Rise-time :
25 Millimicroseconds.

TIME-BASE :

Range :
0.05 second to 1.5 microseconds.

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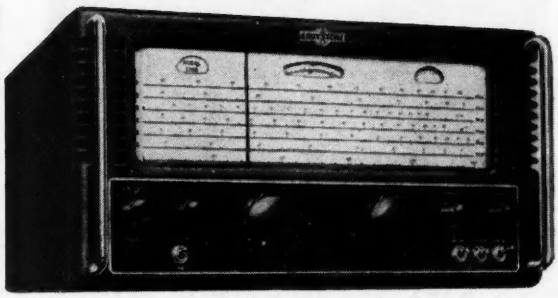

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(Further information on request)

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MAIN +VE Stabilizer	Output	200-500V 250mA	200-500V 250mA	0-500V 250mA	0-500V 250mA	0-500V 150mA
	Number of Ranges	2	2	4	4	1
	Voltage Stabilization	±0.02%	±0.002%	±0.1%	±0.002%	±0.1%
	Effective Output Resistance (max.)	0.2 Ω	0.02 Ω	0.5 Ω	0.02 Ω	0.5 Ω
	Output Ripple (rms. max.)	2mV	1mV	3mV	1mV	3mV
—VE Supply Stabilizer	Outputs	—	—	250V 25mA 0—250V 1mA	250V 25mA 0—250V 1mA	250V 25mA 0—250V 1mA
	Voltage Stabilization	—	—	±0.05%	±0.002%	±0.05%
	Output Resistance (max.)	—	—	1 Ω	0.01 Ω	1 Ω
	Output Ripple (rms. max.)	—	—	2mV	1mV	2mV
Unstabilized +VE H.T. Supply 250mA max.		470V 630V	470V 630V	320V 470V 630V	320V 470V 630V	630V
Unstabilized A.C. Supply		6.3V 10A	6.3V 10A	6.3V 10A	6.3V 10A	6.3V 10A
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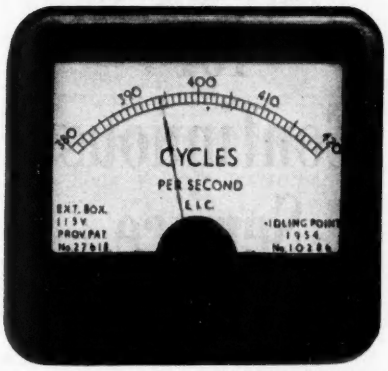

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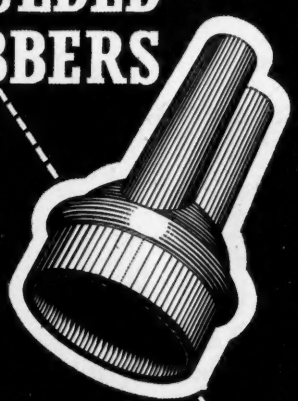

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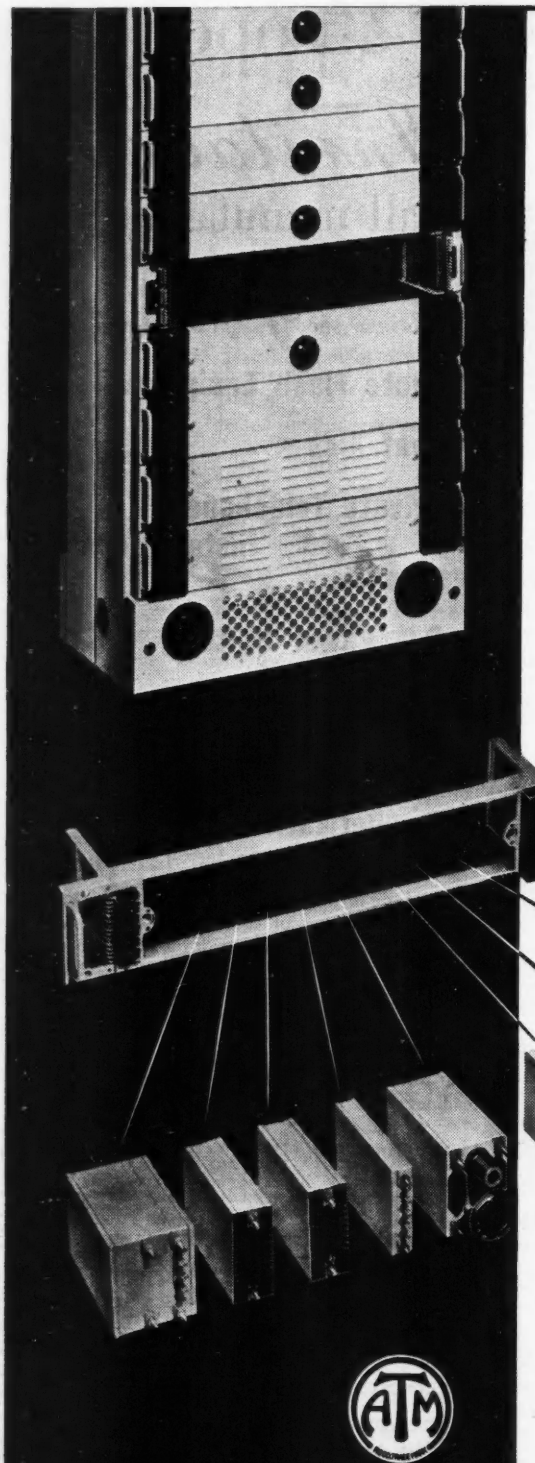

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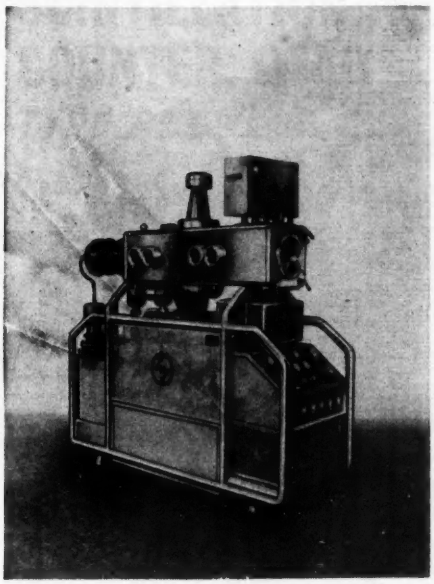

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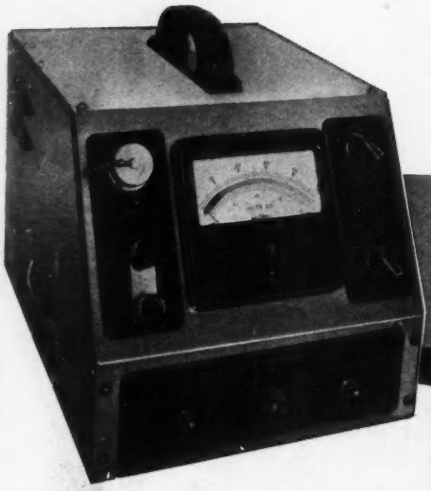

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current drain less than 10^{-11} amps

Based on a well-known A.E.R.E. design, the HYZEE Electrometer Voltmeter has an input resistance of the order of 10^{13} ohms. The instrument can thus be connected to a circuit without disturbing the existing conditions.

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Ranges :	0-10, 20, 50, 100, 200, 500 volts—either polarity.
Accuracy :	±1.25% of scale reading.
Zero Drift :	Less than 1% of full scale deflection per hour after five minutes warming on 10 volt range or less on higher ranges.
Mains :	±10% deviation from the nominal mains voltage will affect the zero and calibration by less than 0.2v. on all ranges.
Power Supply:	200-250 volts 50 c/s.

Typical applications are :—

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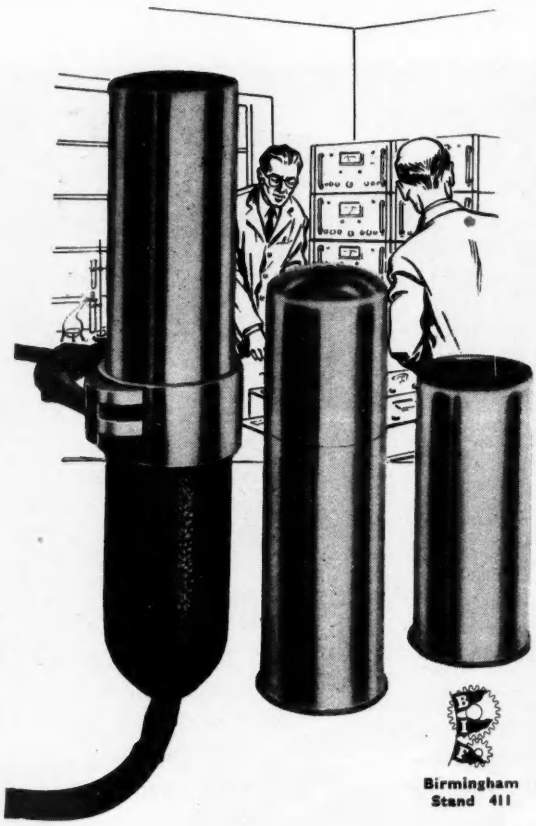

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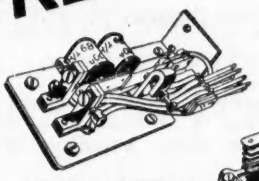

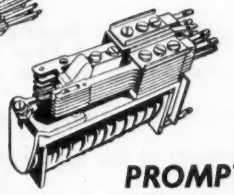

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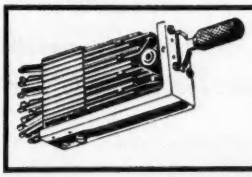

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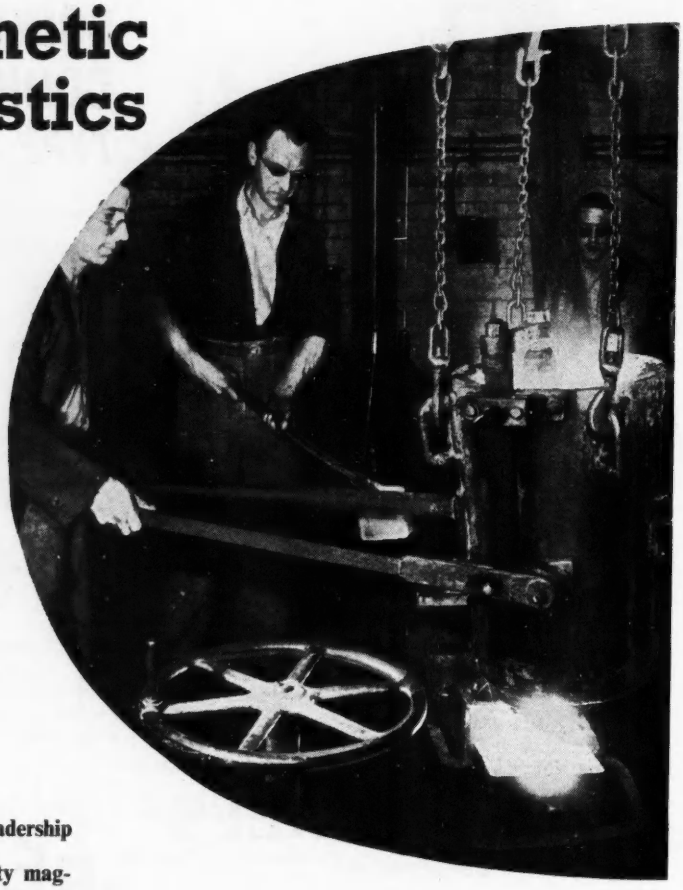

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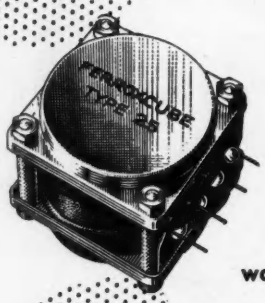

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wound on Ferroxcube cores

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Full details of these and other high grade components now available from Mullard will be gladly supplied on request.

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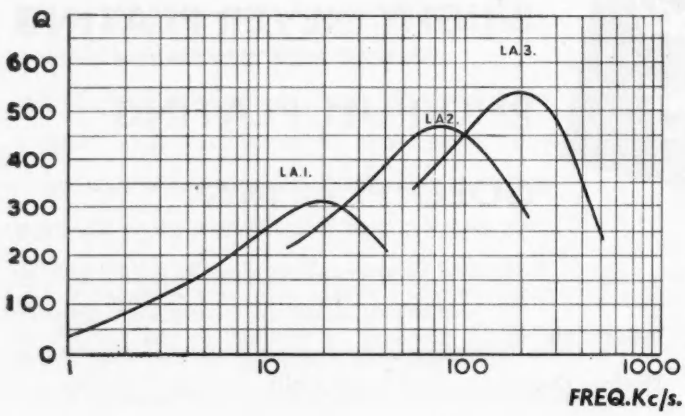

Special Features

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Easily mounted

Mullard

'Ticonal' permanent magnets, 'Magnadur' ceramic magnets, Ferroxcube magnetic cores.

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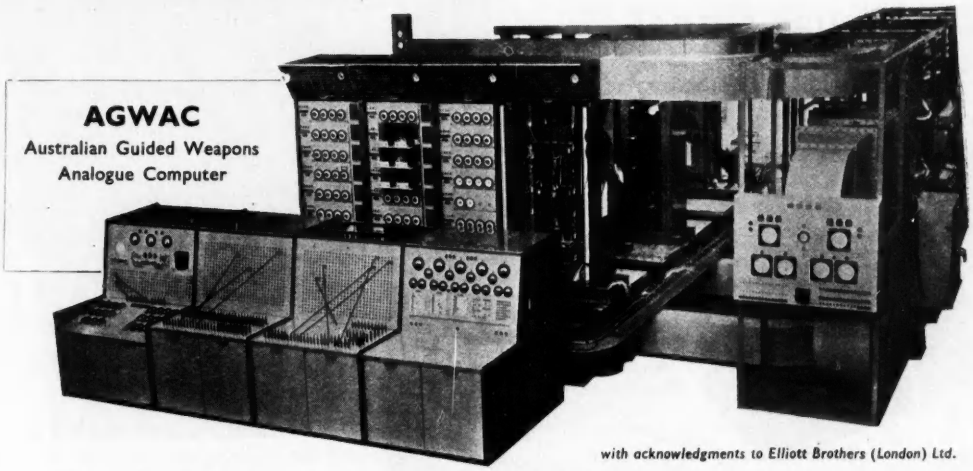
CONSTANTA *high stability resistors used in*



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2. Technical Assistants for work in connection with design and development of thermionic valves.
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Applicants for vacancies (2) and (3) should have Ordinary N.C. or H.N.C. or Inter B.Sc. or equivalent.

The starting salary will be in accordance with the qualifications, experience and age of the applicants.

Applications should be in writing and will be treated with the strictest confidence.

Apply to the Personnel Superintendent.

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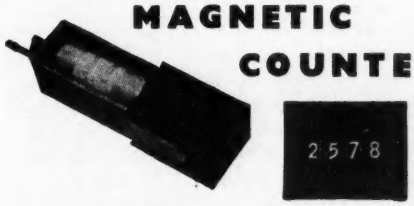

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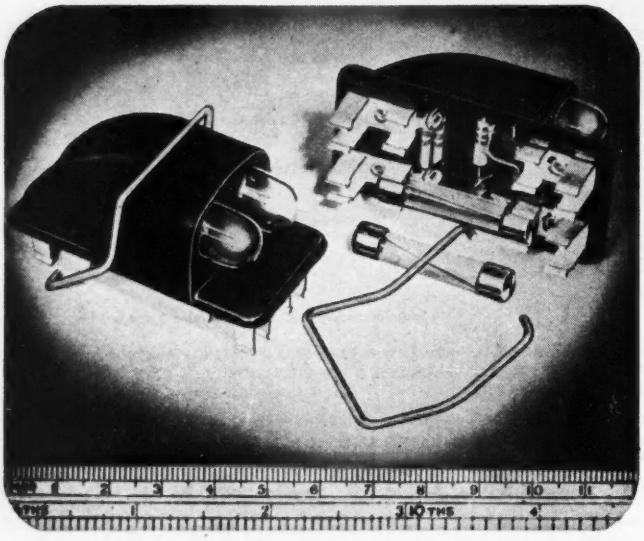
TWIN NEON INDICATOR LID

gives visual signal of fuse failure



This is fitted with two bayonet cap neon lamps with their associated resistor network, and is intended to carry a pair of 1¼ in. x ¼ in. fuses of the standard glass or H.R.C. types.

The lamps are designed *to go out on a fuse failure;* it has been said that it would be more convenient if the lamps were to light, but engineers designing critical and important equipment will not countenance such an arrangement where there would be no indication in the event of a lamp failure, whereas now the worst that can happen is for an apparent "fuse failure" signal when no such failure has occurred.

The lid is designed to be a *direct replacement* for the lid of our standard twin safety fuseholder, thus providing neon indication without any modification to existing circuit wiring. A replacement safety clip ensures non-reversibility.

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The unit is suitable for Relay Control equipment or any similar gear having a number of fused mains or H.T. circuits, and saves the cost of separate indicator lamps with their attendant wiring and additional space requirements.

The neons will glow satisfactorily over a voltage range of 180/250 V. a.c. (r.m.s.) and 220/250 V. d.c.

L.732 PRICE 16/3

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All replies will be kept in confidence.

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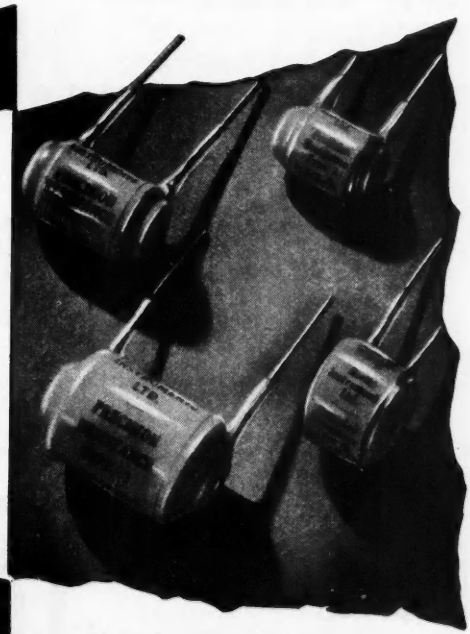
★ Rivlin Wire Wound Resistances fully comply with Services specifications.



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DELIVERY 14 TO 21 DAYS

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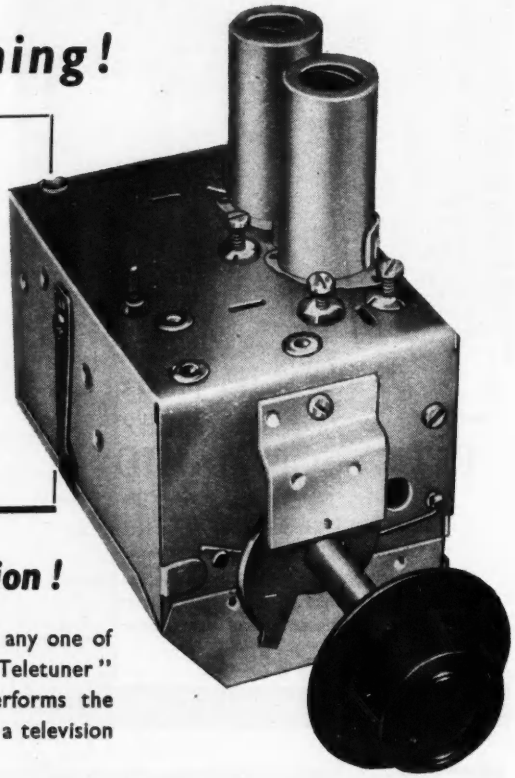
Cyldon

"TELETUNER"

(TRADE MARK)

Type TV.12



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No. 26. Mica Compression Trimmer.

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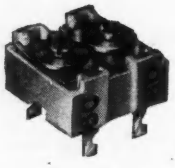

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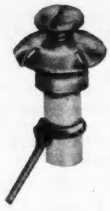

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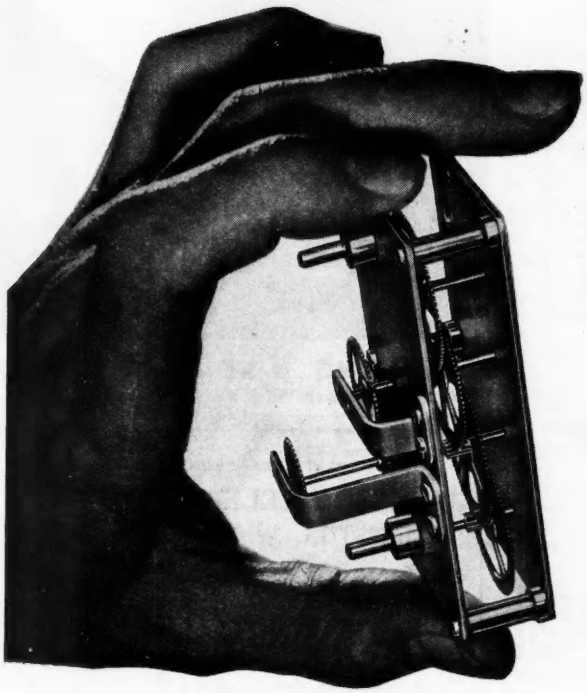

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"Duralumin" is one of a comprehensive range of light alloys developed by James Booth & Company Limited, and these modern materials are being increasingly used with great advantages in electrical engineering and electronics. Our Technical Sales Section will always be pleased to offer advice entirely without obligation.

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1. Circuit Development and Application Engineers for Colour Television investigations.
2. Circuit Development and Application Engineers for Black and White Television development work.
3. Engineers for development work on Television and F.M. Amplifier problems. Previous experience in V.H.F. or F.M. required.
4. Cathode Ray Tube Development Engineers for development work on colour and black and white tubes. Previous experience on cathode ray tube development or design required.
5. Application Engineers for work in connection with Customer problems on Television, Radio and F.M.
6. Engineer for design of test equipment for Colour, Black and White Television and allied development work.
7. Engineers for Circuit development and Application work on Transistors.

The above applicants should have a good Engineering or Physics degree or equivalent, but vacancies also exist for candidates with H.N.C. or equivalent qualifications.

The vacancies are a result of a large expansion in the Company's activities.

Good salaries will be paid to suitable applicants and the positions are progressive and carry the advantages of a Pension Scheme.

The starting salary will depend on the qualifications, experience and age of the applicants.

Applications in writing, which will be treated with the strictest confidence, should be sent to the Personnel Superintendent.

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This Electric Counter is designed primarily for 230 volts, A.C., supply. The Counter can be left energised for an indefinite period without damage. Provision is made for running conduit to the counter case.

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2. A number of men for posts in
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6. Men for posts in the field of electronic instruments
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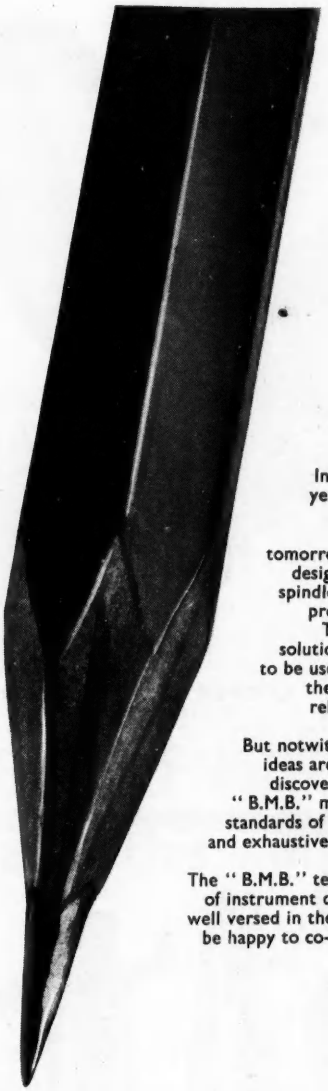
7. Men for research on cold cathode tubes. (Ref. RK)
8. Physicists and physical chemists for research in Solid State Physics. (Ref. RP)

Applications, quoting reference number of post or posts for which applicant wishes to be considered, giving age, summary of qualifications and experience, to Personnel Officer.



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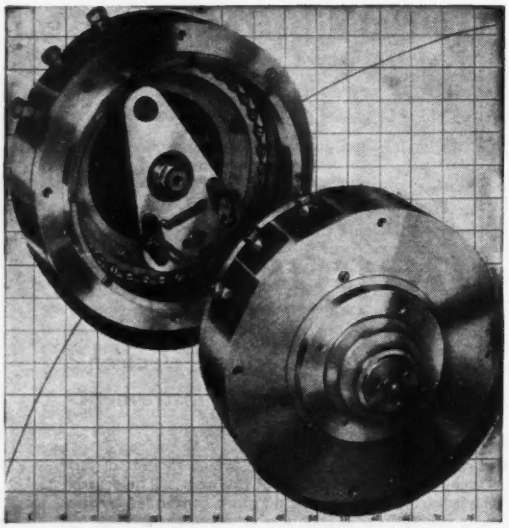

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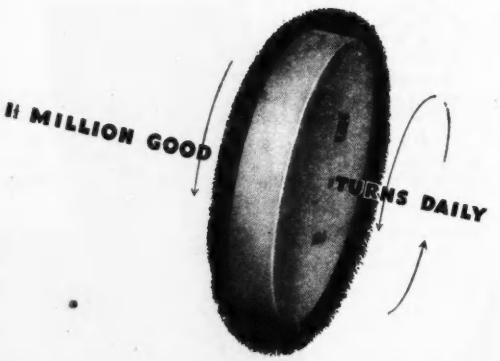

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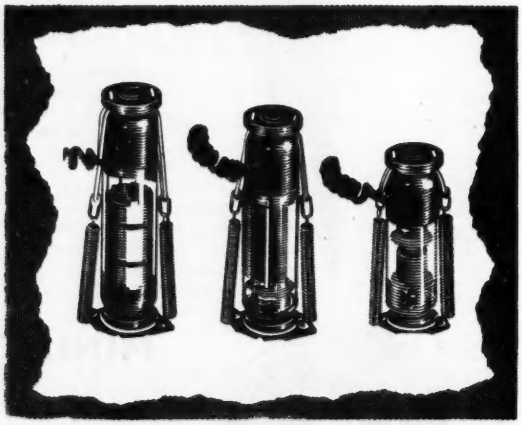

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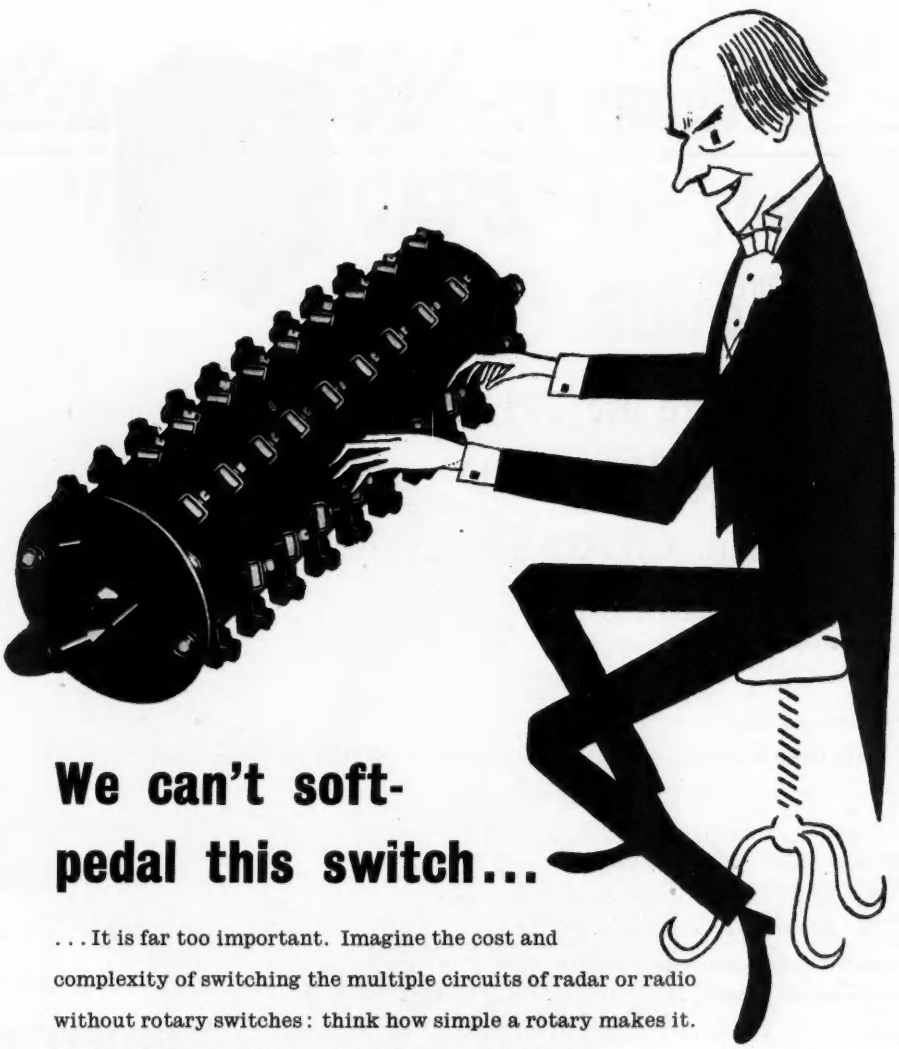

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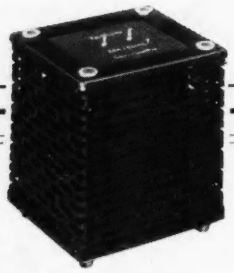

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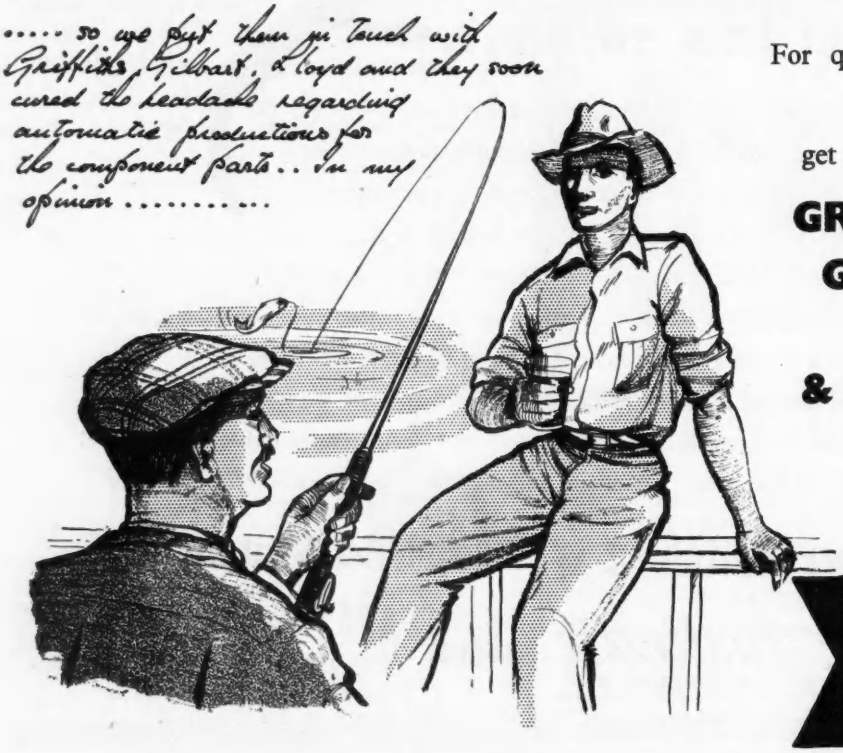
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Tolerance available ± 20%, 10%, 5%					
HIGH STABILITY RESISTORS					
HS3	½ watt	¼ watt	750	1 ohm to 500 megohms	1.1" × 0.1"
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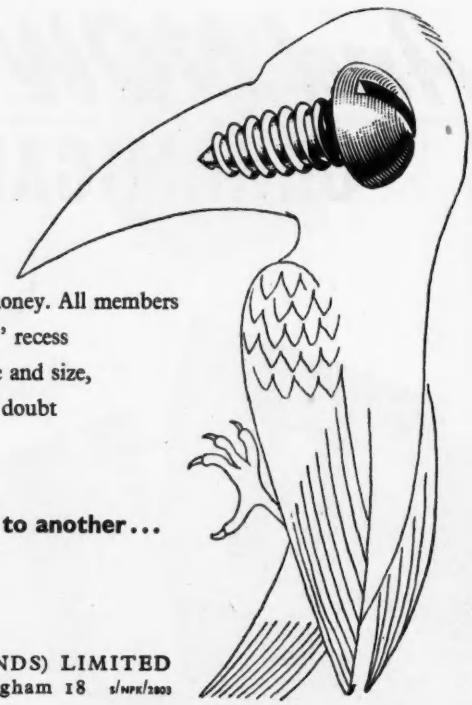

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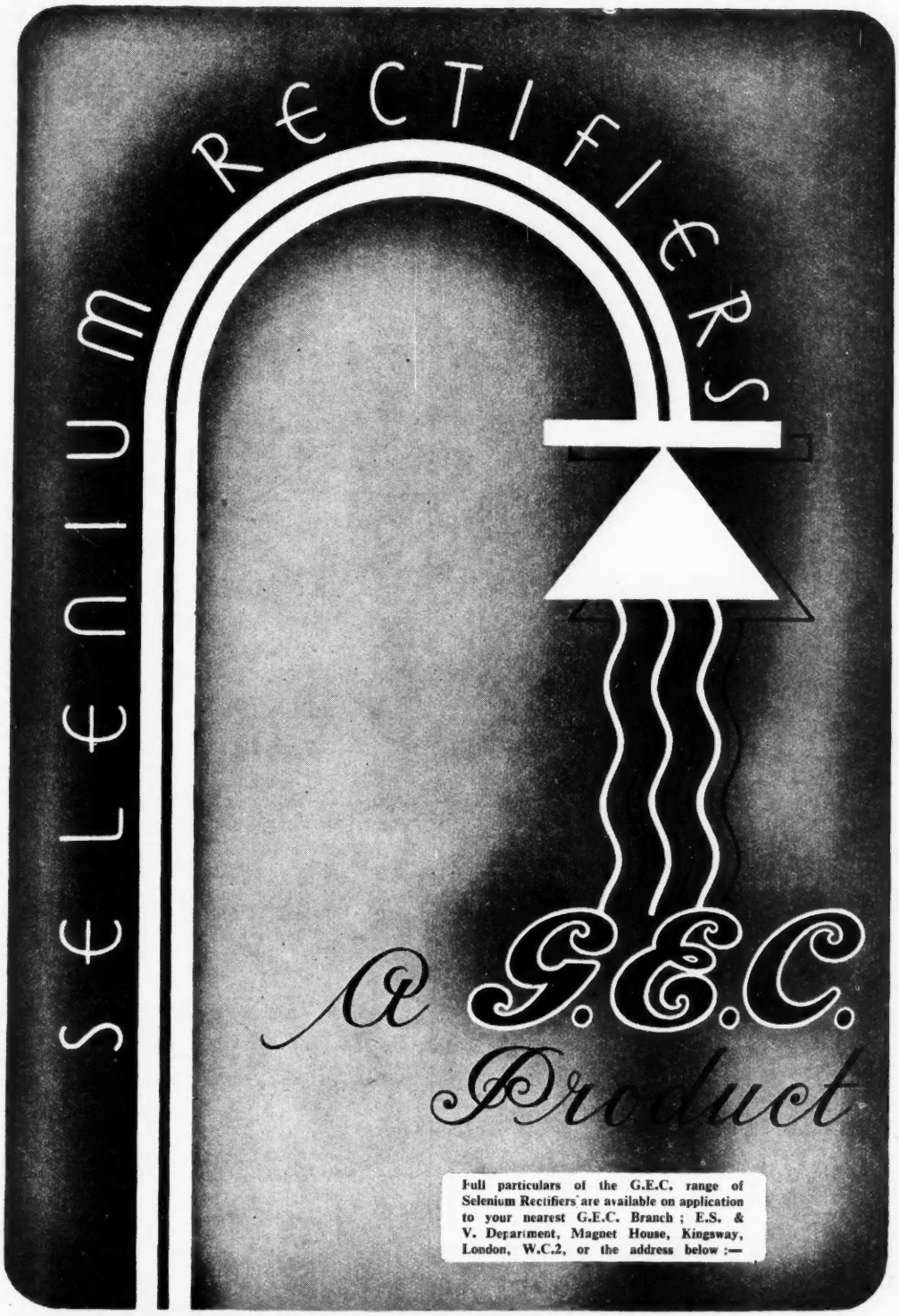
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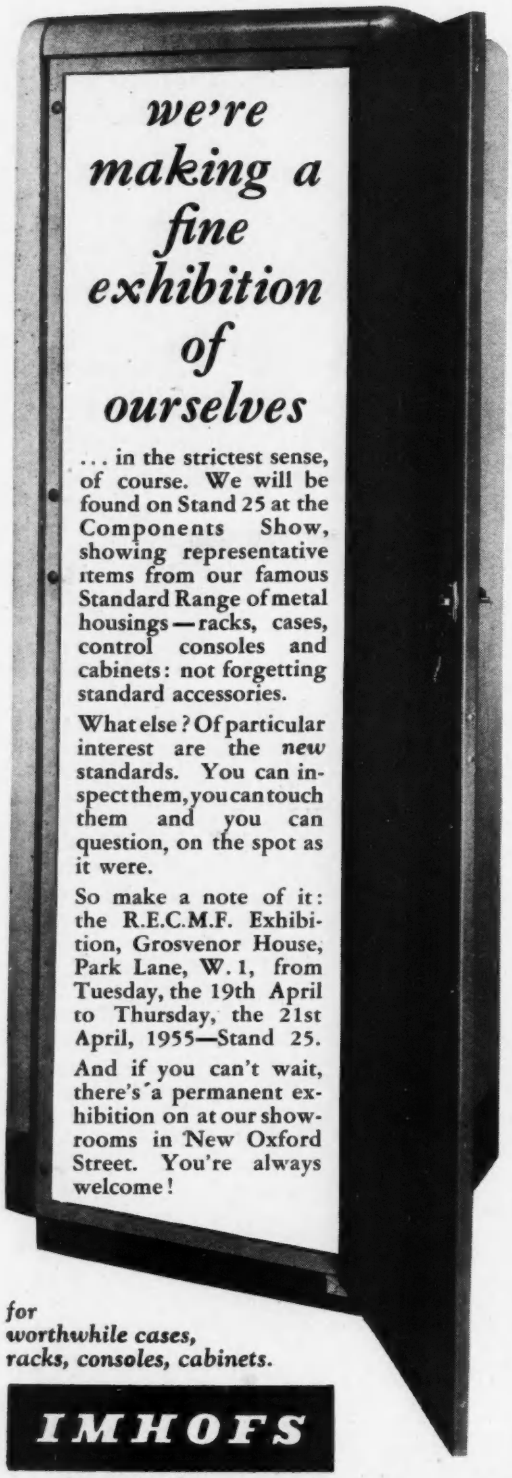

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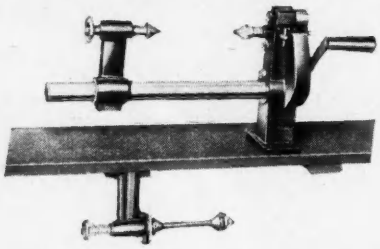

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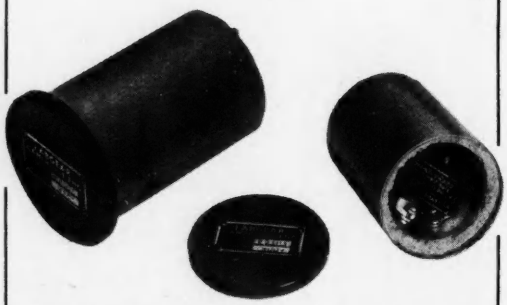

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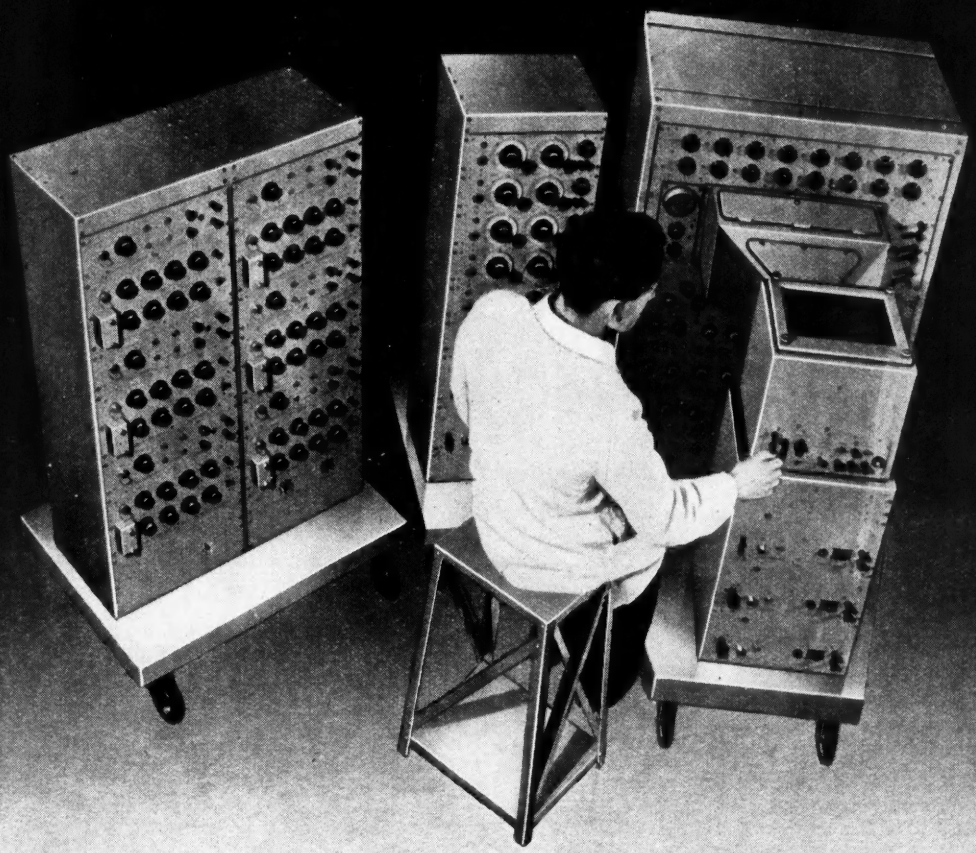

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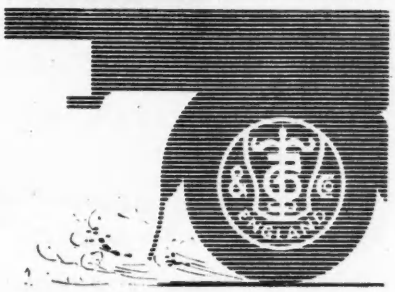

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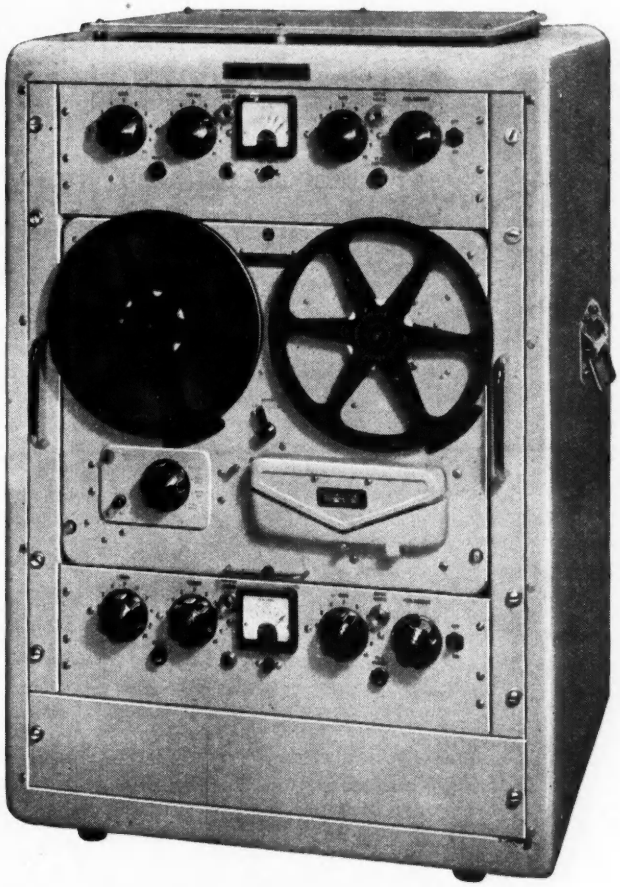

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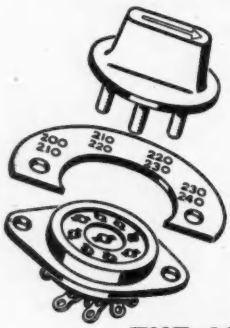

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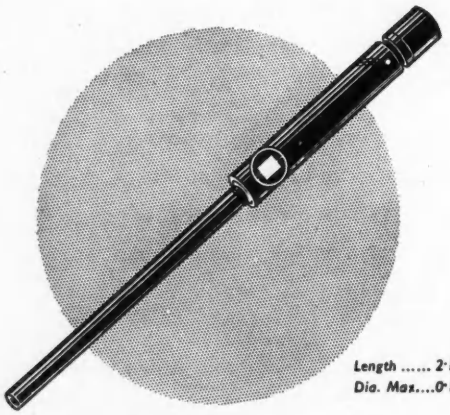

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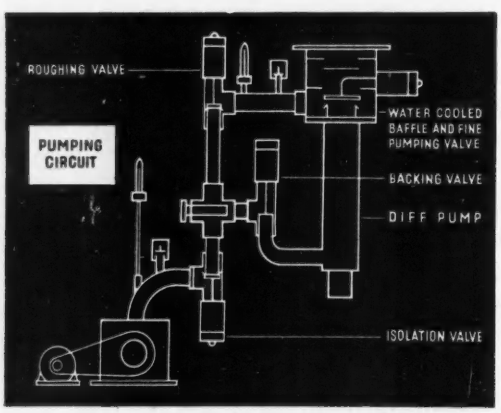

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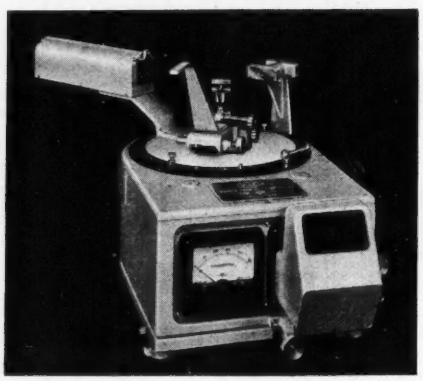

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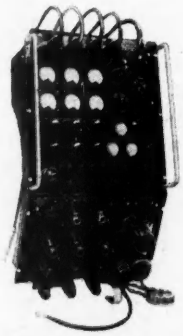

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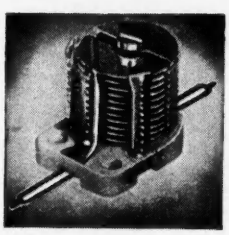

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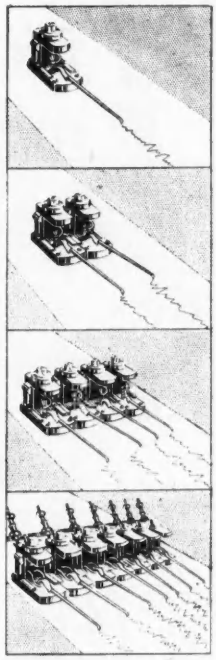

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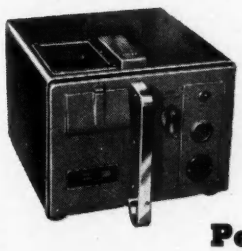

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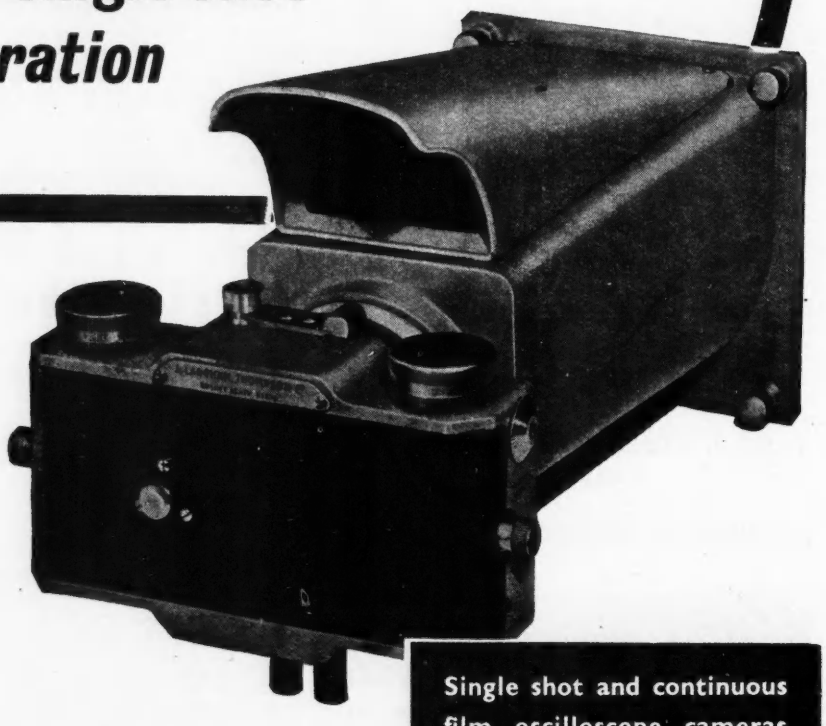

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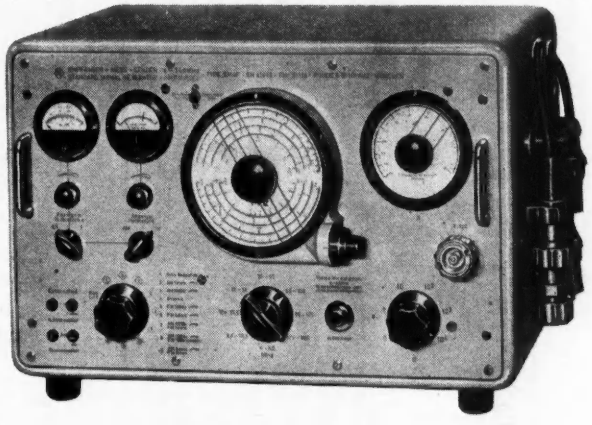

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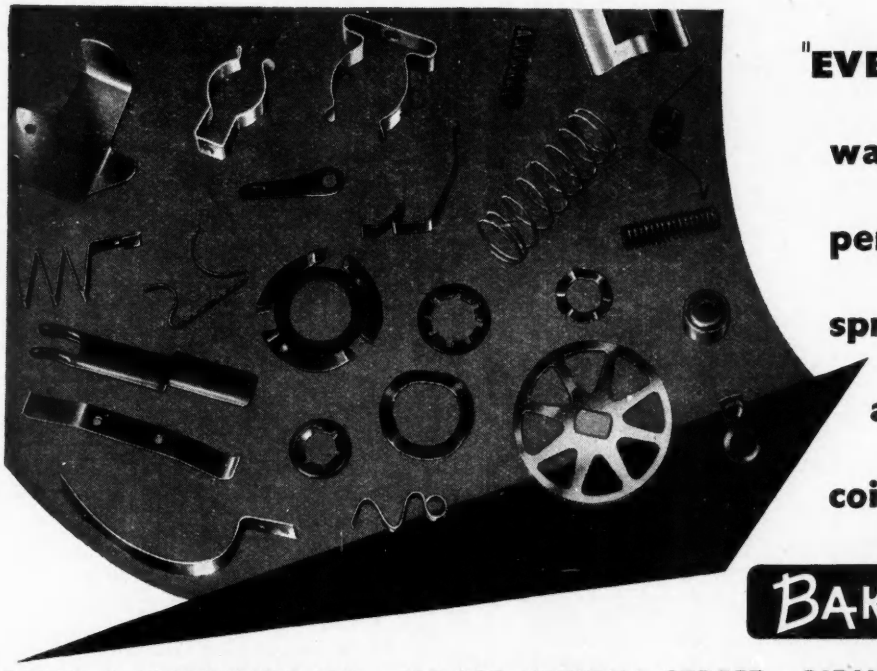

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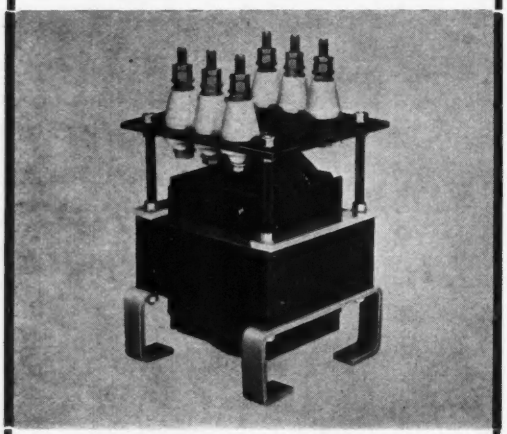

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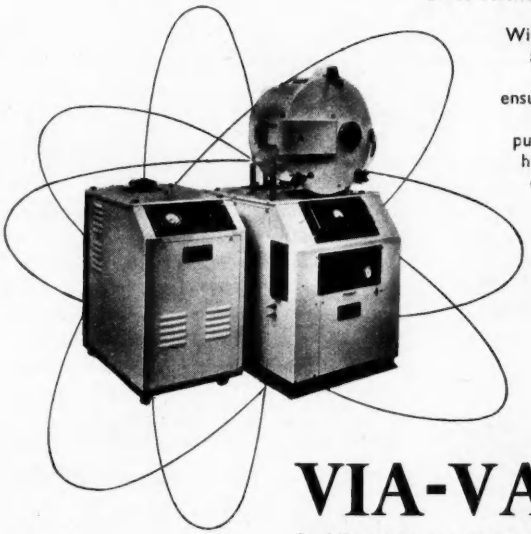

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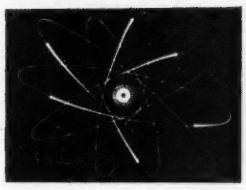

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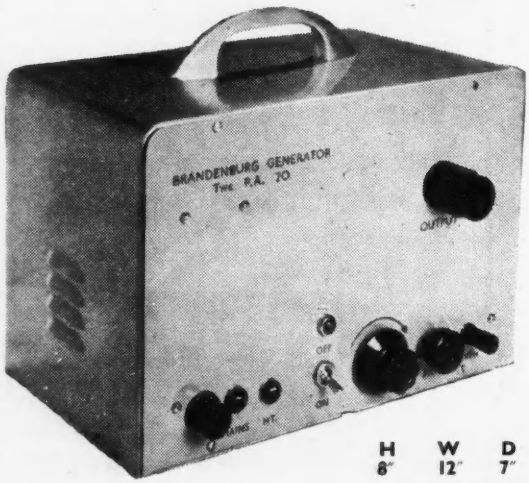

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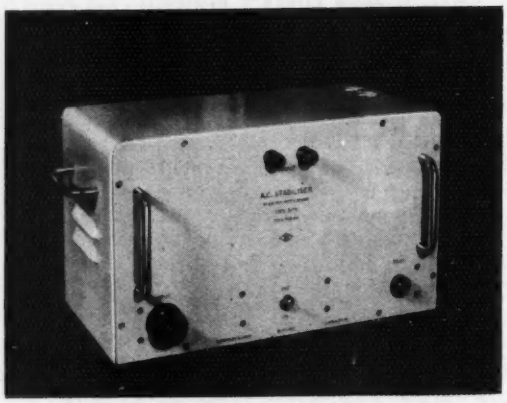

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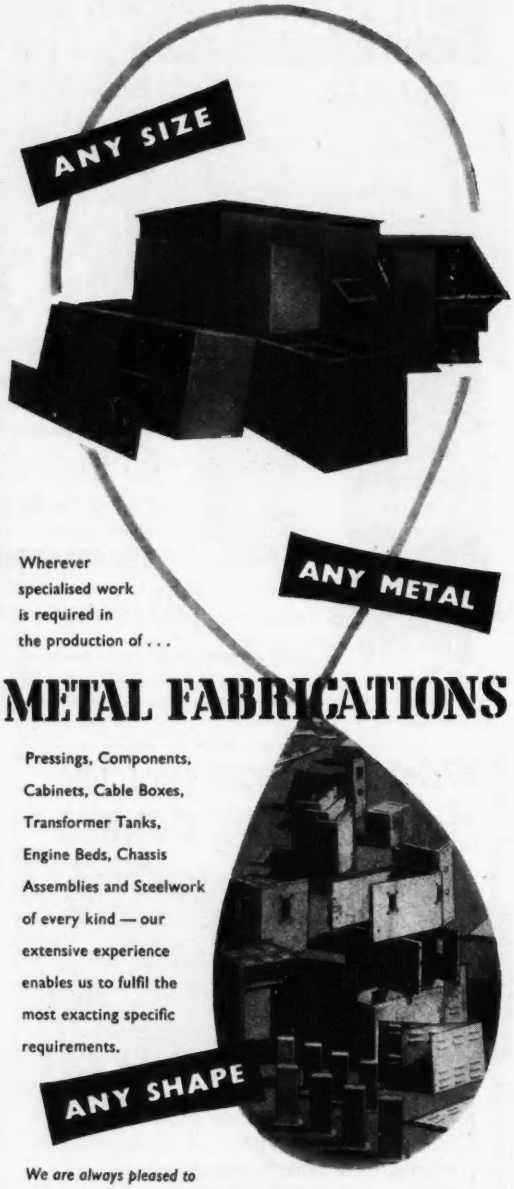

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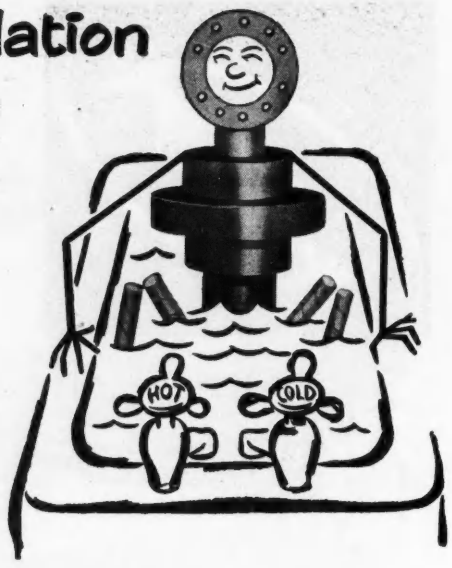

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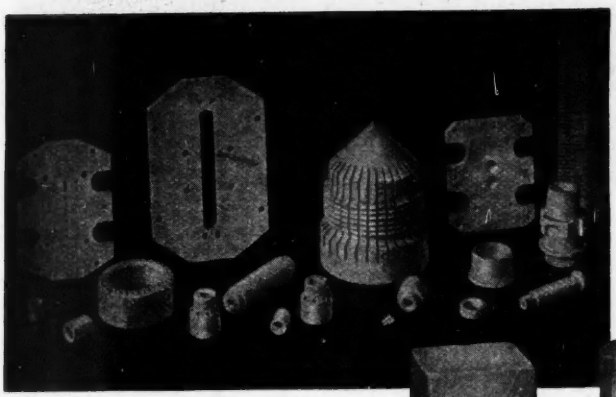

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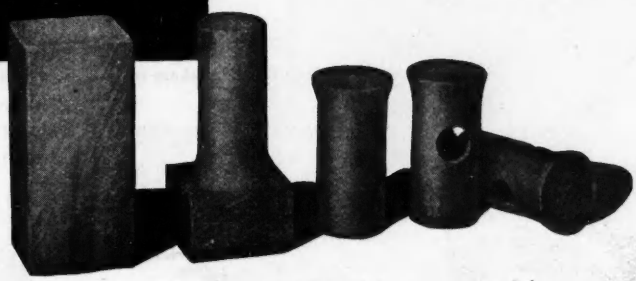

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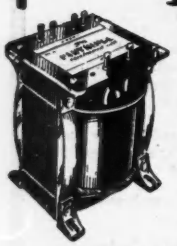

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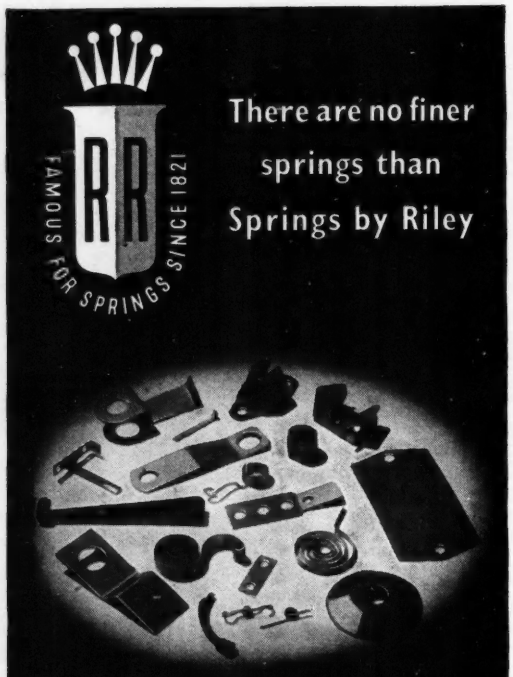

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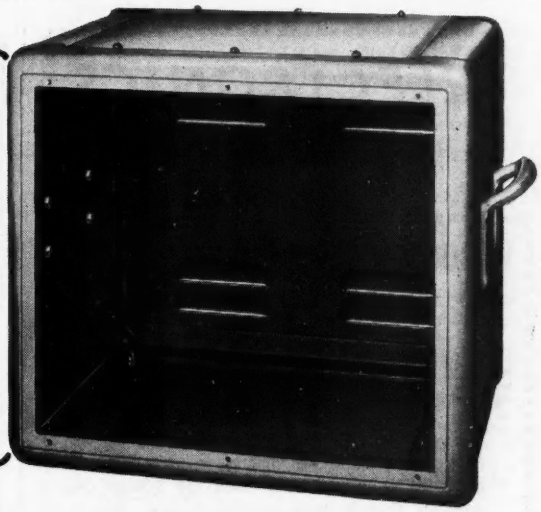

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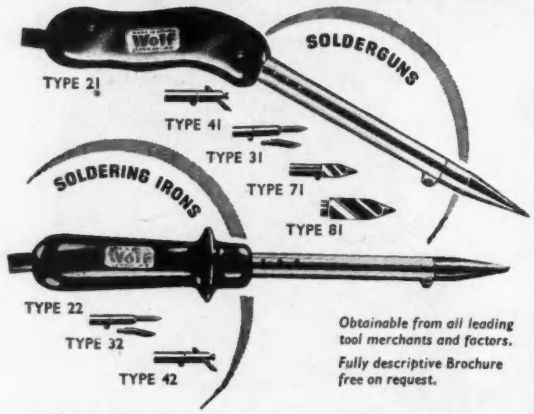

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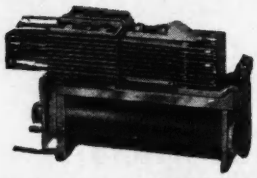

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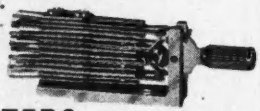

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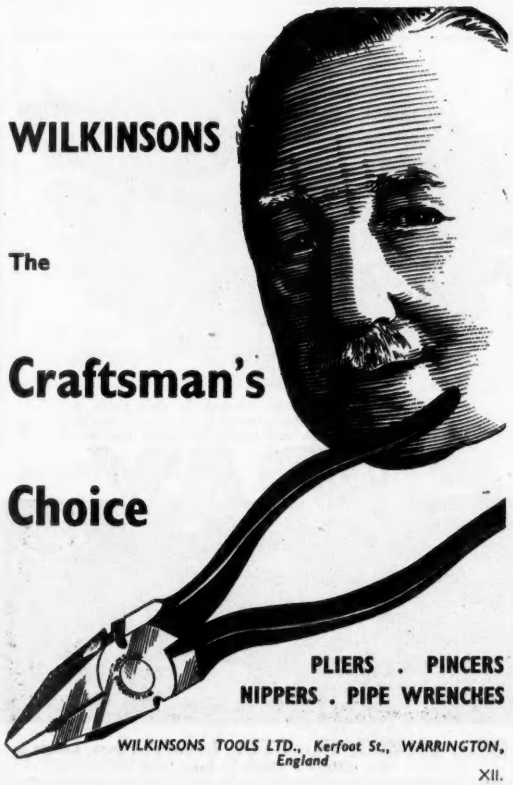

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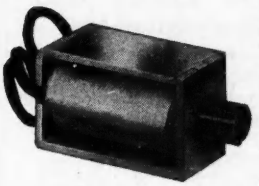

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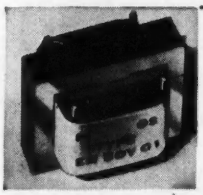

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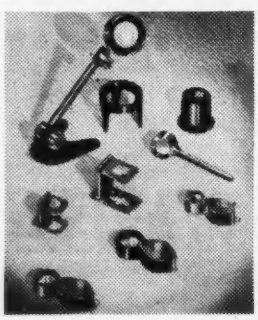

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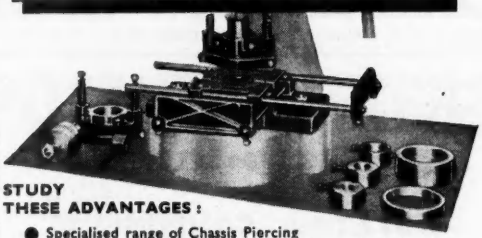

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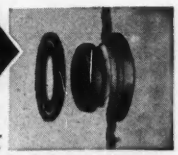

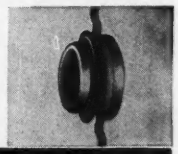

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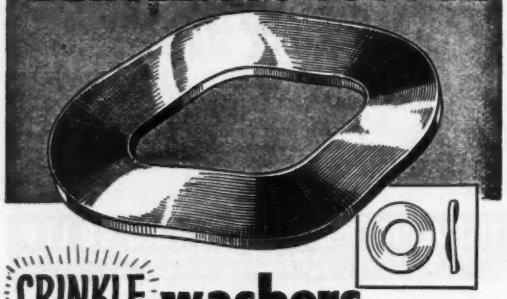

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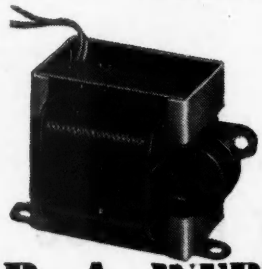

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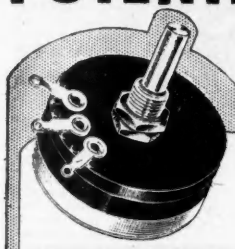

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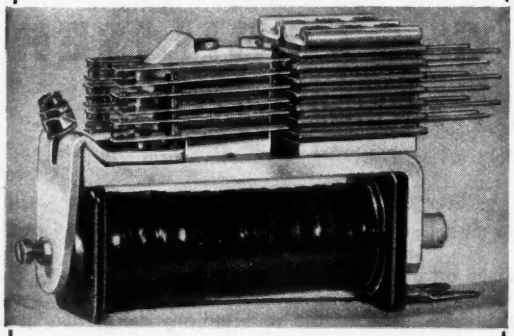

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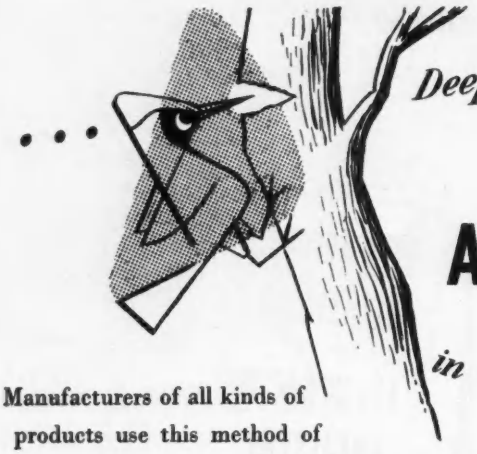

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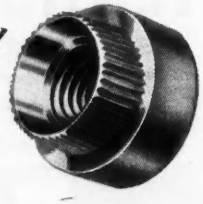

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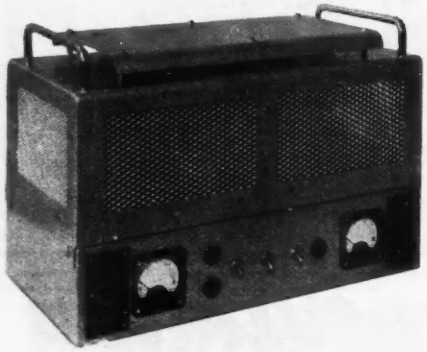

PERFORMANCE DATA

STABILITY. ±0.05% for input voltage changes of at least ±10% at all loads and for normal frequency variations.
REGULATION. Within ±0.1% for changes from no load to full load.
WAVEFORM. Total introduced harmonic content within 3% (mainly 3rd and 5th) under average conditions.
REACTIVE LOADS. Above performance maintained for loads of P.F. from 0.8 to unity, lagging or leading.
INPUT VOLTS. (Nominal) 210, 220, 230, 240, and 250, switch selected.

★ Even greater constancy of output voltage than with earlier model.

★ Increased output—up to 1 amp.

★ Safety device incorporated to avoid any dangerous rise in output voltage in event of failure of any part of the unit.

★ Optional provision of voltmeter and ammeter to measure input and output voltages and output current.

★ Stabiliser can be adapted at small cost to stabilise the radiation emission from light sources such as filament lamps and Nernst filaments.

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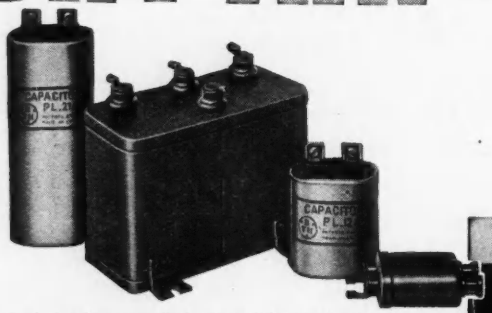

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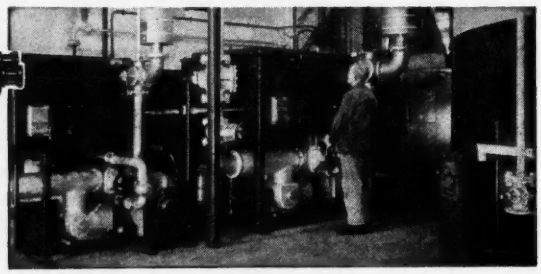

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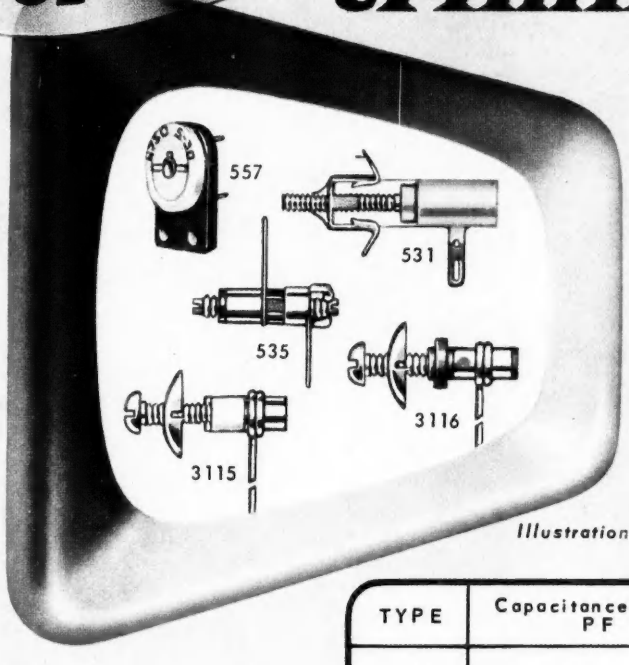

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535	0.7 – 3	500
557	1.5 – 7 3–12 5 –25 5–30 8–50	350
3115	0.5 – 3 1– 4	750
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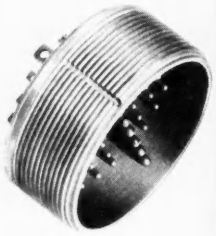

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